PRACTICAL PLANT GUIDE BOOK

PERTINENT ANSWERS TO BAFFLING MAINTENANCE PROBLEMS

The

Practical Plant Guide Book

Covering in simple question-and-answer style more than 124 problems in operation and maintenance of electrical and associated mechanical systems in mills and factories

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Contents

Preface

"Industrial Engineering's" editors have received hundreds of letters during the past four years, asking what to do in this case, how to make that change, in fact, presenting every conceivable form of problem that troubles plant operating and maintenance men.

A study of these letters has enabled the editors to determine definitely the problems that are annoying operating men most.

And into this "Practical Plant Guide Book" have gone the answers to these operating kinks, given by practical men who know the solutions that have worked best for them in similar contingencies. Material selected in this fashion—actual solutions to bothersome points—are bound to make a valuable collection of aids for plant man's use.

You'll find the arrangement convenient, as the grouping under four sections and the comprehensive index in the back make every fact quickly accessible.

Use this book often—refresh and enlarge your knowledge with the tested practices it contains.

Motors and Generators

Changing Phase, Calculating Windings; Tests, Cleaning, Drying, Replacing; Armatures, Brushes, Commutators

Cost of Changing Two-Phase Motors to Three-Phase

QUESTION.—The local power company is planning on changing its system from two phase to three phase. This will involve a corresponding change in a large number of motors ranging from 5 hp. to 50 hp. I should like to know if there will be any loss of efficiency in the motors as the result of this change. Also, please tell me the general procedure involved in changing motors from two phase to three phase, what troubles are likely to be encountered and about what the cost per motor or per horsepower will be.

Fort Smith, Ark. V. L. H.

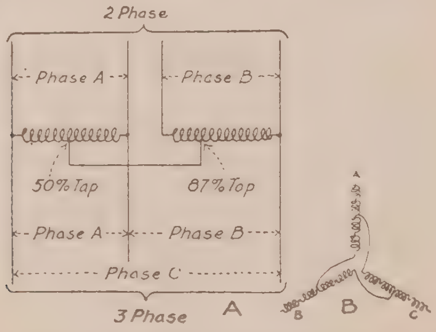
ANSWER—In answer to V. L. H. in a late issue, we have recently arranged to gradually change a large installation of motors from two phase to three phase, in order to make various installations under our supervision flexible in interchange of equipment and be able to purchase motors from stock. Current for this installation is generated at two phase, 440 volts. As a simple solution of the problem we connected two auto-transformers as shown in *A* of the illustration.

As will be seen, we connected the two-phase leads to the busbars at the switchboard and distribute three-phase current over the same feeders which supplied the two-phase motors. If a large number of motors are grouped on one feeder, V. L. H. can connect two auto-transformers to his two-phase circuit at any convenient point in his wiring system and connect the three-phase supply leads to three of the two-phase leads, as shown.

By this method it will not be necessary to change the two-phase motors until trouble develops. Then they can be rewound either for two phase or three phase. Either two-phase or three-phase motors can be connected to the same wiring system provided the proper wires are used for the three-phase motors.

To determine the proper size of auto-transformers a graphic wattmeter chart should be taken from the present installation and a 30-min. average maximum demand obtained. The main auto-transformer should have a capacity of approximately 15 per cent and the teaser transformer 8.5 per cent of this quantity. These percentages are sufficiently accurate for practical purposes.

As an example, if the 30-min. average maximum demand is found to be 100 kva., the main auto-transformer should be of 15-kva. capacity and the teaser of 8.5-kva. capacity. The only cost involved will be the purchase and installation of the two auto-transformers, if the wiring is large enough to carry the three-phase current.



A, two auto-transformers used to obtain three-phase current from a two-phase supply. B, winding of two-phase motor, connected star-delta for three-phase operation.

Few, if any, two-phase motors in actual service can be reconnected for use on three-phase circuits without a loss in capacity at the same temperature rating. This is due to the fact that the cross-section of copper and number of turns in a two-phase winding are different from those in a three-phase winding.

Practically all two-phase motors can be reconnected for three phase with balanced voltage, and correct within 5.5 per cent of the two-phase nameplate voltage rating. The output will, however, be about 20 per cent less than the two-phase nameplate rating. To get balanced voltage using all coils, the winding should be grouped for three phase, but instead of being connected in either star or delta it should be connected star-delta by connecting the ends which would ordinarily be connected together in the star winding, to the middle winding of the next group, providing that the middle connection is not within a pole group. This is shown in *B*.

In a six-pole, two-circuit winding, each winding should have two pole groups connected in star and one in delta. It will take a winder from four to six hours to make this connection.

From observation it appears that at least one of the large manufacturers of motors has practically standardized on full-pitch windings for two-phase motors and approximately 85 per cent of full pitch for three-phase motors. This is probably due to the fact that in two-phase motors, the windings are not interconnected, and currents of higher harmonics are not liable to cause serious trouble with the winding. With three-phase windings, however, and especially delta-connected windings, there is a possibility that the motor may be seriously affected by the current of the third and perhaps other harmonics. By chording the winding at approximately 85 per cent of full pitch, this harmonic current will be either eliminated or sufficiently reduced to prevent serious effect on the winding.

For this reason if a two-phase motor, which is wound with the full-pitch winding, were connected with a star-delta connection outlined in the preceding paragraphs, there is a possibility of the delta portion of the winding having a circulating current of the period of the third harmonic, which would be super-imposed on the power current delivered by the three-phase circuit.

An industrial plant or repair shop should be very careful about making any changes in the winding of motors which will reduce the nameplate capacity or materially change the characteristics of the motors. Anyone making such changes should have a definite and clear understanding with the owner of the motor, so that in case of a burn-out there will be no misunderstanding. For this reason it is safe to recommend complete rewinding of motors rather than changing the characteristics by reconnection. Reconnecting from three phase to two phase or *vice versa* can ordinarily be safely done only when the person making the changes is directly responsible for the operation of the motors and knows what to expect in consequence of the change, but is, nevertheless, willing to take the chance. CHARLES R. SUGG.

Electrical Engineer,
Atlantic Coast Line Railroad Co.,
Wilmington, N. C.

Calculating Starting Resistance for D.C. Motors

QUESTION.—Will someone please tell me how the amount of resistance that is used in the starting rheostats of shunt, compound and series d.c. motors is computed? (2) How are the different voltages obtained on the various taps of the compensators for a.c. motors and what are their usual values in percent of full-line voltage?

Albert, W. Va. F. H.

ANSWER—Replying to F. H., while the calculations as a whole are rather complicated, they are all based upon Ohm's law.

It may be said first that good, sound judgment must be used in every case, as the drives for different machines vary greatly and these variations must at all times be considered, especially in the case of large drives and on important machines with special characteristics.

For instance, a drive on a machine requiring constant torque and starting under full-load condition with probably an allowable maximum motor starting current of say 180 per cent of full-load current, cannot be considered in the same manner as a large fan which starts under no load, the load increasing with the speed of the motor. If F. H. will notice closely the catalogs of the various controller manufacturers, he will see that each starter or controller is adapted only for a certain kind of service and the apparatus is intended only for that service specified. Disregard of these precautions is usually accompanied by dissatisfaction with the apparatus and the manufacturer is blamed unjustly. In the past these complaints have been legion and the larger industrial plants today usually have a works engineer or industrial engineer who properly selects and applies apparatus of this nature.

Motor control and starting apparatus is usually divided into several classifications. A simple starter is a starter and nothing more. If used otherwise a burnout is usually the result. A controller is designed for the control of motors or other electrical devices requiring similar control. The types of equipment and methods of control are many. A good work on this particular subject is Fox's "Principles of Electric Motors and Control" published by McGraw-Hill Book Company, New York, N. Y. This book covers everything the average maintenance man can use on this subject and the principles are very clearly explained.

Assume that we wish to calculate the starting resistor for a 35-hp. shunt motor operating on 230 volts, 130 amp. full-load current. Assume that the resistance of the armature brushes, leads, etc., is 0.02 ohm. Since the maximum starting current is to be limited to 180 per cent of full-load current, 130 amp. $\times 180 = 234$ amp. As the line voltage is 230 volts, then by Ohm's law 230 volts $\div 234$ amp. $= 0.983$ ohm. Since it will require 0.983 ohm to hold the maximum current inrush to 180 per cent of full-load value, it is evident that the resistance of the armature, leads, brushes, etc., is included in this total, as they are in series with the motor armature. The resistance of the armature was taken as 0.02 ohm. Then $0.983 - 0.02 = 0.963$ ohm to be included in the starting resistor. This resistance will hold the maximum current rush down

to about 234 amp. This inrush of current is only momentary, for the armature starts to revolve the instant the rheostat is moved to the starting position and as the speed of the motor increases the cutting of the flux of the shunt field by the armature conductors generates a back or counter-emf. in the motor, which opposes the line voltage and limits the current flowing from the line. The starting resistance permits only a safe current to flow when the armature is stationary, in order to protect the motor windings. When the rheostat is moved to the second position, another peak or inrush takes place and the armature further accelerates, allowing the line current to drop again to a safe value. This operation is repeated until the motor has accelerated to its full-load speed, at which time the counter-emf. holds the line current to its full-load value or at a value corresponding to the load placed upon the motor.

I have found the following table, which gives the per cent of the total resistance in the starter, for each step of a five-step starter, to be very useful:

1st step = 30 per cent of total ohms.
2nd step = 24 per cent of total ohms.
3rd step = 19 per cent of total ohms.
4th step = 15 per cent of total ohms.
5th step = 12 per cent of total ohms.

Applying this table to the problem above, we would have:

1st step $= 0.963 \times .30 = 0.2889$ ohm.
2nd step $= 0.963 \times .24 = 0.2311$ ohm.
3rd step $= 0.963 \times .19 = 0.1830$ ohm.
4th step $= 0.963 \times .15 = 0.1445$ ohm.
5th step $= 0.963 \times .12 = 0.1155$ ohm.

It will be noticed that the resistance of the different steps varies, but the total always must remain the same for a given condition of load. Authorities differ on what constitutes the proper amount of the total ohms for each step, based upon their varied experiences. The results, however, generally are the same under average conditions.

The same starter can be used either on a shunt-wound or a compound-wound motor, under ordinary conditions, but where variable- or adjustable-speed motors are used and the larger part of the speed adjustments are made by a field rheostat changing the shunt field flux, somewhat different formulas must be used, taking into consideration these conditions.

For starting a series motor the ordinary type of starter is used, but as a series motor with a starter is rarely used except on hoists of the smaller type, and on cranes and other machines of like nature, a regulating resistor and controller are used. The formulas for the design of this type of resistor are more complicated.

Automatic controllers of the magnetic- and remote-control types are designed along similar lines for a

given service, with the exception that less steps are required in the resistors for starters. Speed regulators, automatic control panels used for speed regulation of various machines, are designed with a certain number of steps, depending upon the amount of reduction required. The number of steps varies widely; on some machines three to five steps are considered sufficient. On others the complexity of the work requires even 10 or 15 steps, and on some of the large printing press controllers 18 or 20 steps are used.

In order to design a satisfactory controller, speed regulator or starter most of the factors have to be known and the available motor data must be furnished by the motor manufacturer. In addition, the designer has to consider other factors, such as the type of drive, the apparatus it is to be used on, the starting time the resistors are to be in actual service, starting torque, braking features and many others. P. S. PENDER.

Chief Engineer,
Metropolitan Engineering Co.,
Granite City, Ill.

Calculation of Rotor Winding for Squirrel-Cage Motor

QUESTION.—I have a 1-hp., 220-volt, Type RI, single-phase, General Electric motor, which I wish to rewind for three-phase operation. I have calculated the winding for the stator, but do not know how to go about figuring the squirrel-cage winding for the rotor. Can any reader give me some help in this matter?
Oakland, Calif. B. B.

ANSWER—Regarding B. B.'s question, the best method to follow in this case is to use the old rotor winding as a base. In all repulsion-starting types of motors, the rotor winding is short-circuited at a certain speed. After this stage the rotor acts as a squirrel-cage winding, having the correct distribution of current to provide the required running and pull-out torque, with a certain per cent of slip.

The first step in changing the wound rotor for three-phase operation, is to remove the brush rigging and short-circuiting device. The latter includes all springs, weights, and the copper necklace, when used. Next, turn and polish the commutator, put a bronze wire band on this clean surface, and solder it to the commutator. On radial commutators the band will have to be put on the narrow width of the necks so as to obtain a substantial job.

The above procedure will give the same results as a squirrel-cage winding and if greater starting torque is required the turns per coil and size of wire can be varied. More turns of a smaller size of wire will increase the starting torque and increase the full-load total losses, while less turns and a larger size of wire

will decrease the starting torque, increase the starting current and decrease the full-load losses. If it becomes necessary to rewind the rotor, due to a burned-out winding, or to change the starting torque, the commutator can be removed from the rotor and the ends of each coil connected together, so that each coil becomes a short-circuited loop.

When rewinding, consider the coils per cell as being all in parallel. For example, assume a rotor having 37 slots and 111 commutator bars or three single coils per cell, each coil consisting of three turns of one No. 12 d.c.c. wire. Now when the rotor is short-circuited, the three coils are in parallel or equivalent to 37 coils, each consisting of three turns of three No. 12 d.c.c. wires in parallel. This point should be remembered when rewinding in order to change the torque and will enable B. B. to meet any starting conditions with a suitable winding. A. C. Roe.

Wilkinsburg, Pa.

Will Two A.C. Motors Operate Satisfactorily in Parallel?

QUESTION.—We have a turntable driven by a variable-speed, slip-ring a.c. motor. This motor is too small and rather than incur the expense of buying one motor that is large enough to handle this job, we are considering buying another motor, a duplicate of the present one, and connecting it directly to the table, so that the two motors will both drive the table in parallel. Will the motors operate satisfactorily in parallel? Can we operate both motors from the same secondary resistance and controller, or should we use two drum controllers and two independent resistances? I will greatly appreciate any information and experiences that other readers can give me on this subject.

Omaha, Neb. G. C. B.

ANSWER—In reply to the question asked by G. C. B., we have two, three-phase, slip-ring, Allis-Chalmers, motors, one rated at 400 hp. and the other at 200 hp., running in parallel on a copper rod mill drive. These two motors are direct-connected to opposite ends of the same shaft.

These motors are both fed from the same oil switch; one trip coil with current transformer being used for overload protection for the 400-hp. motor and the other trip coil for the 200-hp. motor.

Each of the motors also has a double-pole, push-button-operated, magnetic contactor. Red indicating lamps are installed on the panel with the push buttons, informing the operator when the contactor for either motor is closed.

The machine is normally started without load and can be started only by means of the 400-hp. motor; this motor has a secondary controller and resistance of the usual type. We have added an interlocking

contact at the bottom of the controller which makes contact on the last point and is connected in the push-button circuit to the contactor coil of the smaller or 200-hp. motor.

Hence, only when the drive is up to speed, can the second motor be started. This is accomplished simply by pushing its start buttom. The rings of this motor are permanently short-circuited by means of German silver strips connected across the brush holders. The purpose of these strips is to insert a low resistance in the secondary of this motor, and the length of the strips was adjusted by trial until the motor was carrying its proportionate share of the load. In case the load is light either motor may be tripped off the line and the load carried by the other.

In the case of the turntable mentioned, since the motors are variable speed and both will be required at starting, I believe the simplest method would be to provide a separate secondary resistance and controller for each motor, gearing the controllers together so that they will operate together as a unit.

It would be possible to parallel the motor secondaries and use one resistance if the rotors have the same voltage characteristics and are phased out properly when connected. In this case a resistor of greater carrying capacity would be required. However, the present controller might serve, if of generous design.

The second motor will not need to be as large as the original motor unless twice the horsepower of the first motor is required. W. W. Lankton.

Ass't Electrical Engineer,
Detroit, Copper & Brass Rolling Mills,
Detroit, Mich.

Tests on Motors Do Not Check Nameplate Data

QUESTION.—We have three 200-hp., 600-r.p.m., 60-cycle, three-phase, 440-volt, wound-rotor, induction motors, that are used to drive tube mills in our cement plant. According to the nameplate, the full-load, primary current is 245 amp., while the full-load secondary current is 346 amp. On making a test on one of the motors, I found that with the belt off the primary current was 125 amp. Upon putting the belt back on the pulley and loading the motor, the primary current rose to 275 amp., while the secondary current went up to 150 amp. Upon increasing the load, the primary current reached 350 amp. and the secondary current 275 amp. According to the nameplate the primary current should be less than the secondary current, while the tests show just the opposite. The temperature rise on the motors so far has stayed below 40 deg. Can some reader tell me what is the matter with these motors?

Ragland, Ala. R. I. F.

ANSWER—In answer to the question by R. I. F., when measuring the secondary current of slip-ring induction motors operating at normal speed, it is necessary to remember that the current frequency of the secondary

or rotor circuit is very low. As a matter of fact, the frequency of this circuit is equal to the slip of the motor.

The ordinary slip of induction motors is from 3 to 5 per cent. This means that the frequency in the secondary circuit is two or three cycles per second, when operating at full speed. When measuring the current in the secondary of a 200-hp., slip-ring motor, the natural tendency would be to use a current transformer connected to a 5-amp. meter. The reading of the meter would then be corrected in accordance with the ratio of the current transformer. However, these current transformers are ordinarily designed for a frequency of 25 to 50 cycles, and they will not read accurately on frequencies as low as two or three cycles per second. If the current in the secondary circuit is measured with the rotor locked, that is, with the rotor standing still, the readings obtained when using the current transformer and the 5-amp. meter will be accurate.

A meter which will measure the motor nameplate current probably could be used, although if this is done care must be taken to see that excessive current does not flow through it when the motor is started. This excessive current can be avoided by providing a heavy, single-pole, single-throw knife switch, which directly short-circuits the ammeter during the starting period. If this switch is opened after the motor is running, the reading can be taken without danger to the meter.

In discussing the actual current values recorded by R. I. F., it seems apparent that he has tried to use a current transformer, and this has resulted in a much lower reading than the value of the secondary current actually present, because of the very low frequency in the secondary circuit. It should be understood that the primary circuit of an induction motor refers to the stator windings, which are directly connected to the a.c. supply, and that the secondary or rotor circuit corresponds to the secondary of an ordinary transformer.

In making tests of this kind, care should be taken to see that the voltage on all three phases is maintained at practically the same value, and that this value is not more than 5 per cent less than the rating of the motor. In other words, on a 440-volt circuit the voltage must be maintained within 5 per cent of the 440-volt figure, if results are to be obtained which will agree with the nameplate data. It is also best to test the current in all three phases, or at least in any two of the lines, in order to make certain that balanced conditions are present.

Judging from the results, R. I. F. obtained, that upon increasing the load the primary current became

350 amp., while the secondary current was only 275 amp., it might seem that the relative positions of the two windings of the motor had been misunderstood. However, it is believed that the error is in the use of a current transformer and that R. I. F. understands perfectly that the primary winding is the stator winding. This latter point has been suggested merely because it is very often overlooked.

JAMES B. HOLSTON.

Commercial Engineer,
Wagner Electric Corp.,
Chicago, Ill.

Changing Slip-Ring Motor to Squirrel-Cage Type

QUESTION.—I wish to change the rotor of a wound-rotor induction motor so that it will operate as a squirrel-cage motor. I have rewound the stator for 900 r.p.m. instead of 600 r.p.m. as originally. I have removed the clips from the rotor winding and have the coils ready to short-circuit on themselves. Will it be necessary to change the rotor coil span in order to make the motor operate efficiently? Should I put a ring at each end of the rotor and connect all of the rotor conductors to it, thereby making the winding quite similar to a squirrel-cage winding? Is there a quicker or better way than I have mentioned for converting the wound-rotor winding into a squirrel-cage winding? I would like to obtain the opinion of other readers as to the advisability of making this change in the winding.

Bessemer, Ala. O. S.

ANSWER—The data given do not state whether the rotor is wave or lap would; however the following discussion will cover either case. If the rotor winding is of the wave-wound type, short-circuit the rings; or if rings are to be removed, short the three leads from the winding, making a permanent connection. Do not disturb the present connections of the individual coils; that is, leave the winding as it was for 600 r.p.m. Then remove the insulation from the top layer of leads for a distance of approximately 2 in. back of the clips. A *bronze* wire band (No. 10 B. & S. gage) is then run over the copper leads thus exposed. This band should be soldered to the leads which it covers, with a tin solder, not half-and-half solder. The points where the connections are made to bottom leads for star leads, or reversing jumpers, should be connected to the top clips.

The object of the bronze wire band is to connect the top and bottom leads together, thus shorting all coils. This is the quickest way of arriving at this result. However, if O. S. has all the clips removed and the leads bent in towards the center of the coil it will be satisfactory to short each coil on itself. The coil pitch in this case will be satisfactory.

It will not be necessary to connect a ring to the ends of the coils; neither will it be necessary to cut open the rear of the coils, nor to add a ring to the rear of the coils.

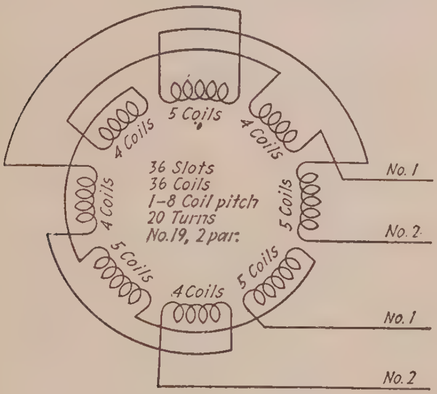
The motor with the rotor connected in this manner will have low starting torque and will require the use of the high-voltage tap of the starting compensator.

A. C. ROE.

Wilkinsburg, Pa.

Changing Single-Phase Motor for Three-Phase Operation

QUESTION.—I have a General Electric, form C, 60-cycle, 220-volt, 1-hp., single-phase, 1,800-r.p.m., motor connected as shown in the accompanying diagram. The armature has 36 slots, and 36 coils, having 20 turns of No. 19 wire wound two in parallel. The coils are arranged in groups of 4 and 5 coils per group as shown. (1) How should this winding be connected



for use on a single-phase supply? (2) It is desired to connect the motor and operate it from a three-phase supply. Is it possible to change or reconnect the winding to secure this result? I shall greatly appreciate any information or help that readers can give me about this motor.

Brooklyn, N. Y. W. M.

ANSWER—W. M.'s inquiry indicates that the motor is a two-phase machine with an ordinary squirrel-cage rotor. This is an old type motor wherein the necessary revolving field for starting on single phase is obtained by means of phase displacement in the two stator windings. The starting connections are shown at *A* in the accompanying diagram, and at *B* are shown the running connections.

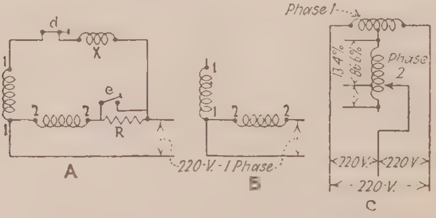
The connections shown in *B* are brought about by opening switch *d* which cuts the reactance *X* out of the

circuit, and closing switch *e* shunts the resistance *R* out of the circuit.

Two single-pole knife switches may be used to open and close the above circuits, but a double-pole, double-throw switch is preferable for then only one handle needs to be manipulated.

In view of the fact that the coil *X* and resistance *R* will be used to carry 15 or 20 amp. for only a few seconds during starting, the size of the wire used in these two coils can be smaller than would ordinarily be used for continuous duty.

If it is desired to use this motor on a three-phase circuit, it will be necessary to use a "T" connection as



Method of operating a two-phase motor from a single-phase or three-phase power supply.—The single-phase starting connections are shown at *A*, and at *B* are shown the single-phase running connections. The connections after a single-phase motor has been reconnected for operation on a three-phase circuit are shown at *C*.

shown at *C*. You will notice from the diagram that the reactance and the resistance are not required when the motor is operated on a three-phase circuit.

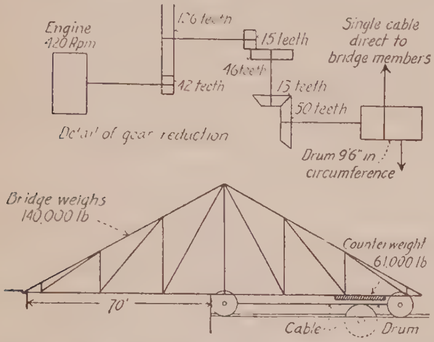
In diagram *C* of the accompanying illustration the midpoint of phase winding 1 is connected to one end of phase winding 2, and 13.4 per cent of phase winding 2 is cut out. Since 13.4 per cent of 36 coils is nearly five, the closest approximation to the exact reduction required will be obtained by cutting out six coils. The best way to reduce the phase 2 windings is to cut out coils from the four groups, say two coils from each group of five coils, and one coil from each group of four coils. J. B. HOLSTON.

Commercial Engineer,
Wagner Electric Corp.,
Chicago, Ill.

Size of Motor Required to Operate Drawbridge

QUESTION.—I wish to know how to determine the size and speed of motor required to operate a drawbridge that is now operated by a steam engine. The diagram shows the general layout of the bridge. It weighs about 140,000 lb. and travels 70 ft. in 45 seconds. It is supported on four steel wheels 30 in. in diameter with a 12-in. face, running on steel rails. The bridge is pulled back and forth by a steel cable running on

a drum which is driven by the engine through a gear reduction; this could be changed to a worm gear if necessary. The speed of the engine is 420 r.p.m. while the drum turns at 10 r.p.m. I do not know the horsepower of the engine, or is it equipped to take an indicator card, but the following data may help: Duplex



engine (both cylinders receive same pressure); steam pressure, 50 lbs. per sq.in.; cylinders 8 in. diameter by 10-in. stroke; speed 420 r.p.m.; non-condensing. It will be necessary to use a two-phase, 60-cycle, 550- or 2,200-volt motor. I shall be very grateful for any help readers can give me.

Quebec, Que., Can. W. S. B.

ANSWER—Replying to W. S. B., the power required to propel a drawbridge weighing 140,000 lb. plus the weight of a counter-weight of 61,000 lb. can be determined from the formula:

$Hp. = (W \times L \times S) \div (33{,}000 \times e)$.

Where W = total weight of structure in tons (201,00 $\div$ 2,000).

L = lb. per ton friction (assume 30).

S = speed in feet per minute.

e = combined efficiency of gearing, rope friction, etc., say 0.8.

If the speed of the drum is 10 r.p.m., and the circumference is 9.5 ft., the speed of the bridge is $9.5 \times 10 = 95$ f.p.m.

Therefore, $Hp. = (201{,}000 \times 30 \times 95) \div (33{,}000 \times 0.8 \times 2{,}000) = 10.8$ hp.

It should be noted that the above calculation is made on the assumption that friction is on the basis of 30 lb. per ton. If the wheels bind on the rails this value may be 60 hp. instead of 30 hp., and the horsepower required to propel will be twice as much.

To determine the horsepower rating of the motor, a rule of thumb method is to multiply the horsepower required to propel by two, and use the nearest standard rating. In this case 10.8 hp. $\times$ 2 = 21.6 hp.

A 20 hp. motor should be about right. The reason for multiplying by 2 is because a heavy structure, like

a bridge, with large inertia may require a large amount of power to accelerate it although a comparatively small amount is required for propelling it after it is up to speed.

A closer check, taking account of the WR^2 values of the different masses being accelerated would be as follows:

WR^2 of bridge = (201,000 ÷ 0.8) × [95 ÷ (2 × 3.1416 × 810)]^2 .... = 87.5
WR^2 of gears and other rotating parts (assumed) .... = 2.0
WR^2 of rotor of motor........................ = 15.0
Total WR^2 of all moving parts referred to motor pinion 104.5

Assuming the bridge is up to speed in 5 sec., the torque required of the motor for acceleration is only
(104.5 × 810) ÷ (308 × 5) = 55 lb. at 1-ft. radius.

The torque for propelling plus the torque for acceleration is 70 + 55 = 125 lb. to be exerted by the motor when bringing the bridge up to speed, where the propelling torque is (10.8 × 5,250) ÷ 810 = 70 lb. at 1-ft. radius.

A 10-hp., 900/810-r.p.m. motor has a full-load torque of 65 lb. and a maximum starting torque of approximately 135 lb. Allowing for loss of torque due to low voltage, this value would be considerably less and under winter conditions when friction is high due to hard grease and presence of snow and ice, a motor of this size probably would not be able to break the static friction and get the bridge moving.

A 20-hp., 900/810-r.p.m., slip-ring type, crane motor will be able to exert a maximum torque of approximately 260 lb., or a little more with normal voltage and frequency applied at the motor terminals. This seems quite a margin over 125 lb. figured above, but besides the possibility of a higher friction than 30 lb. per ton there is always the possibility of low voltage. The torque varies as the square of the voltage, so that if the voltage happens to be 490 volts instead of 550 volts the maximum torque becomes 260 × (490 ÷ 550)^2 = 207 lb., which does not leave as great a margin for acceleration as is the case when full voltage is present on the local power company's system.

If either 550-volt or 2,200-volt power is available, I suggest the lower voltage, as a much better proposition can doubtless be secured from the motor manufacturer on both motor and control equipment.

A 900-r.p.m. (synchronous speed), crane-type motor is suggested. This is a standard 60-cycle speed and lends itself satisfactorily to gearing. A higher-speed motor would be cheaper but less satisfactory as far as gearing is concerned.

With a speed of 10 r.p.m. at the drum, the speed at

the 42-tooth pinion will be $10 \times (50 \div 13) \times (46 \div 15) \times (126 \div 42) = 354$ r.p.m.

This is somewhat lower than the speed given by W. S. B. as the speed of his engine is (420 r.p.m.). Since the motor speed is going to be a little more than twice the engine speed, the 42-tooth pinion should be replaced by one having a smaller number of teeth; or assuming 810 r.p.m. is the correct operating speed of the new motor, $42 \times 354 \div 810 = 18$-tooth pinion.

R. F. EMERSON.

Industrial Engineering Dept.,
General Electric Co.,
Schenectady, N. Y.

Low-Voltage Generator Will Not Excite

QUESTION.—It was necessary to rewind the shunt field coils of a 50-volt generator of very low capacity, which is direct-connected to a small motor having a speed of about 4,000 r.p.m. It is a two-pole machine having 2,000 turns of No. 37 wire in each shunt field coil. When the winding was completed, the machine generated 55 volts satisfactorily. It was then found necessary to reverse the generator position with regard to the motor, which of necessity reversed the direction of rotation; due to this reversal of rotation the residual magnetism of the generator was lost. When I separately excite the shunt fields from a 50-volt, direct-current bus the generator develops its proper voltage. When I reconnect the fields to the armature terminals I get a reading of only 1 volt. I wish some reader would tell me what is wrong and how I can correct this trouble.

Stamford, Conn. W. E. H.

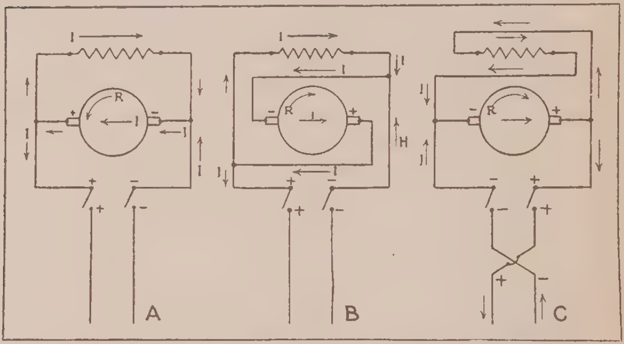
ANSWER—In answer to W. E. H.'s question, I would say that on any direct-current machine there are four conditions which can be changed. These conditions are (1) change from a generator to a motor, or vice versa; (2) change in direction of rotation; (3) change in armature polarity; (4) change in field polarity. If any one of the above conditions is changed, one of the three remaining conditions must also be changed in order to bring the machine back to the same status as it was originally.

In the case mentioned by W. E. H., the direction of rotation was changed. The natural thing to change with the direction of rotation was the flow of current through the armature. When the voltage started to build up, current began to flow through the field coils in the opposite direction to its flow before the change was made. This produced a magnetic flux in the field which was in the opposite direction to the residual magnetism in the field poles, thereby cancelling the same, and preventing generator from generating.

If the armature terminals that were connected to the brush holders had been reversed, the voltage would have built up without any difficulty, for in this case the direction of current through the field coils would not

have been reversed to that formerly obtained and consequently, the residual magnetism in the field poles would not have been killed. This can be done as shown at *A* and *B* in the accompanying illustration.

Sometimes, it is not convenient or permissible to interchange the armature leads on the brush holders.



Relation of direction of rotation, armature polarity, and field polarity, in motors and generators.—At *A* is shown the relation of field current, *I*, armature current, *I*, armature polarity, and direction of rotation *R*, for a generator. To maintain the same status after reversing the direction of rotation of the armature, it is necessary to reverse the armature leads as shown at *B*. This change could also be made by reversing the field connections, as is shown at *C*.

In such cases the change can be made by reversing the connection of the shuntfield coil to the busbar leads, as is shown in *C* of the accompanying illustration.

Probably the easiest way to correcting the trouble that W. E. H. is experiencing, would be to change the direction of rotation of the generator by reversing the direction of rotation of the motor, thereby bringing the generator back to its original operating condition.

J. M. ZIMMERMAN.

Renewal Parts Engineer,
Westinghouse Electric & Mfg. Co.,
Pittsburgh, Pa.

Operating Direct-Current Motor as Generator

QUESTION.—We have a Century Electric compound-wound, d.c. elevator motor rated at 220 volts, 52 amp., 1,200 r.p.m. which we wish to use as a generator to deliver 110 volts, 50-60 amp. I shall appreciate it if some reader will tell me whether it will be necessary to rewind or reconnect the armature, or if there is any way in which we can operate it as it is.

Caguanay, Que., Can. C. R.

ANSWER—Referring to C. R.'s question, probably the most satisfactory results would be obtained by rewind-

ing the armature and fields, if it is desired to use the motor permanently as a generator. Since the load will be only 50 to 60 amp. at 110 volts, and the motor is now rated at 220-volts, 52 amp. it would have approximately the desired output by driving it at a lower speed, say about 600 r.p.m. or at the speed, as determined by test, required to give the correct voltage. If the machine can be belted to the driving motor or other prime mover a test would readily show what size pulley should be used to give the required operating speed.

As elevator motors have a very strong series field which is usually short-circuited or cut out when the motor is up to speed, it will be necessary to cut the series field out altogether when the machine is used as a generator, or install a shunt for it, since there would be difficulty in holding constant voltage if the field were left as it now is. The method described above is a makeshift which will require the least expense and the least number of changes. The shunt fields must be reconnected so as to give approximately the same field current as for the full-voltage condition. This would mean two fields in parallel for a two-pole motor, or two in series with two groups in parallel for a four-pole motor.

If it is desired to maintain the speed at 1,200 r.p.m. additional resistance can be inserted in the shunt field circuit to cut down the field current to give half voltage. A shunt will also have to be placed across the series field to weaken it sufficiently.

If the motor is of the non-commutating-pole type it will probably be necessary to shift the brushes, when acting as a generator, in the direction of rotation.

C. OTTO VON DANNENBERG.

Electrical Division,
General Engineering and Management Corp.
New York, N. Y.

Emergency Excitation for Generators

QUESTION.—For exciting our generators we have one motor-driven exciter which is normally in use. After the station has been completely shut down, we have one steam-turbine-driven exciter which is used for starting. Suppose that when we attempt to start up, the steam-driven exciter should break down. How could we excite our field? Could it be done by using several automobile storage batteries in series? For exciting our generator at no load, we require 60 amp. at 65 volts and it would be necessary for this supply to be on for approximately 10 min. Would it be practicable to use eleven 6-volt storage batteries in series for supplying this excitation? If so, what capacity should the storage btateries have? I shall appreciate any information that readers can give me on this problem.

Medicine Hat, Alta., Can. E. R. S.

ANSWER—Answering E. R. S., the fields can be excited only by the use of another exciter or an emer-

gency battery. In one instance that came up in my experience, only a motor-driven exciter was used and an outside service was depended upon for energy when the station was completely shut down. Provision was made for an interruption in the outside service by putting an extension on the shaft of each generator unit, to which a small generator could be belted. A pulley was provided to fit the generator shaft extension. The small generator was mounted on a truck so that it could readily be moved about, and served its purpose very well. It is assumed that in E. R. S.'s case there are no electrically-operated oil circuit breakers in the station, requiring a battery which might be used as a source of current in emergency.

The fields could be excited by the use of a number of automobile batteries connected in series, but while it is practicable to do so this could not be recommended as a very satisfactory method. Whether the automobile batteries would handle a discharge rate of 60 amp. for ten minutes could be determined only by trying it, or by consulting the manufacturer of the batteries. Although many automobiles require between 50 and 100 amp. or more for starting the engine the duration of the discharge rarely exceeds one minute and is usually much less.

It is assumed, of course, that it is not desired to have a small gas- or gasoline-driven set, similar to the Delco or Kohler, available for this service. However, the ease of providing a shaft extension on which a pulley can be placed for driving the low-capacity exciter, as previously described, is, I believe, the simplest and most practical solution of this problem.

C. OTTO VON DANNENBERG.

Electrical Division,
General Engineering and Management Corp.,
New York, N. Y.

Cleaning Motor Winding

QUESTION.—What is the best method of cleaning motors that are oil-soaked and dirty? Can they be washed in gasoline and baked out in a bake oven to any advantage? What is the best method of handling the gasoline? Should the armatures be dipped in a trough containing gasoline, or should they be wiped with a gasoline-soaked rag? I would greatly appreciate hearing of any other methods used by readers for cleaning oil-soaked windings, as well as the results obtained by using gasoline for cleaning.
Chicago, Ill. R. W. A.

ANSWER—In reply to R. W. A., there are several good methods of cleaning stators. If the stator is very dirty and oily one method is to wash with gasoline under pressure. An ordinary paint spraying appliance, such as the small portable type used for painting armatures and motors, may be used to advantage. After washing the stator in this manner it should be thoroughly heated

and dried out in order to remove such oil and moisture as has penetrated the insulation of the coils. The time taken for this drying process will vary with the condition of the motor; some motors require only 8 or 10 hr. while others require from 24 to 48 hr. This applies to relatively small motors, 100 hp. or under. Larger motors will require more time in proportion.

Another very good method that, while it is a little more expensive is very efficient, involves the use of a regular cleaning fluid such as the cleaning fluid put up by the manufacturers of Pyrene. If this cannot be obtained readily, the regular Pyrene extinguisher liquid may be used. This liquid is an excellent cleaner and evaporates very rapidly. It is safe to use, so far as danger of fire is concerned, but the fumes given off are very offensive and cleaning should be done where there is a plentiful supply of fresh air; otherwise the operator will be made very uncomfortable.

A method which has been used to some extent, but has never met with the approval of very many electrical men, makes use of water under pressure. It has been used on motors that were filled up with dust not containing oil. If an excellent drying oven is available this method may be used with some success, but in my opinion it is best to keep away from the use of water or any other liquid which is slow to evaporate.

If handled by a careful operator, an ordinary, coarse scrubbing brush and a pail of gasoline can be made to give excellent results. After the washing, compressed air can be used to clean out the air ducts, which are usually plugged up. During the past two years the writer has been using a spray gun and gasoline under a pressure of 40 to 80 lb. per sq.in. The pressure used depends upon the condition of the insulation of the coils. If the insulation is old, low pressure must be used; otherwise the tape will be torn off the coils. If the insulation is in good condition and has not been subjected to very much oil, 80 lb. pressure may be used without damage to the tape. We dry the motors out thoroughly before and after cleaning and then give them one or two coats of Sterling black air-drying varnish.

In many old motors where the bearings have been rebabbitted in the plant shop, no provision is made to drain oil from the bearings back into the oil well; consequently it follows the shaft and is blown all through the coils by the fans on the rotors. All sleeve type motor bearings should have a groove cut around the inside at each end and small holes drilled at the bottom to allow oil to drain to the well, instead of following the shaft. LEE F. DANN.

Chief Electrician,
Donnacona Paper Co., Ltd.,
Donnacona, Que., Can.

Drying Out Direct-Current Motors

QUESTION.—One of our largest steel works was recently flooded, due to the breaking of a dam. About 500 direct-current, shunt-wound, 250-volt motors, ranging in size from 10 to 250 hp. have been under water for 10 days. Our problem is to dry out these motors in the shortest time. The greatest difficulty encountered is in drying out the shunt-field coils. Drying out in an oven is rather slow, due to the large number of motors that must be taken care of. I would greatly appreciate learning from readers what methods they would suggest for drying out these motors, particularly the field coils.
Bressoux, Liege, Belgium. P. V. H.

ANSWER—In reply to P. V. H.'s question referring to the drying out of d.c. motors, the writer had a similar experience after a mine explosion in the West where the 500-volt motors used had been under water for several weeks. These motors ranged in size from 5 to 200 hp.

We proceeded at first by stripping the outside insulation off the coils and washing them with benzine. The coils were wiped dry and put in an electric oven used for baking armatures. However, this process was too slow, since the coils dried out on the outside surface only.

It was urgent that we have these motors in operation at the earliest possible time; so we arranged to connect the shunt coils inside the oven in series with a resistor, applying about 75 per cent of normal field voltage, while the oven temperature was regulated at 180 deg. F. for 6 to 12 hr., depending on the size of the coils.

After this treatment the field voltage was raised to normal, the oven temperature was gradually raised to 220 deg. F. and the coils were baked for about 2 hr. The coils were then tested, dipped in a baking varnish, allowed to drip, and baked again for 10 hr. at a temperature of 190 deg. The series and interpole coils were treated as above, except a heavier resistor was used for controlling the increased current required to raise the temperature of the heavier copper. We experienced difficulty in removing the sludge and mud from the armature and interpole coils, but found that by first drying (not baking) the windings and applying a benzine wash, the mud was easily removed.

WILLIAM J. MILDON.

Supt. Power & Equipment,
Madeira-Hill Coal Mining Co.,
Philipsburg, Pa.

Why Does This Motor Run Slow?

QUESTION.—We have two wound-rotor motors, each rated at 325 hp., 2,300 volts, 60 cycles, and 1,185 r.p.m. at full load. Both of these motors are running about 30 r.p.m. below their rated speed. The frequency of the power supply is normal, for the generators are run-

ning at their correct speed of 3,600 r.p.m. About nine years ago the ventilating fan blades were removed from the rotors of the motors and consequently during the summer the windings become quite hot. When the motors are running the pointer of the power factor meters swings continuously. The pumps that are driven by these motors have recently been overhauled, but there was no increase in the speed of the motor. Since the pumps are running at less than rated speed, the motors do not draw rated full-load current. Can some reader tell me what causes these motors to run at less than rated speed and how I should go about correcting the trouble?

Medicine Hat, Alta., Can. E. A. S.

ANSWER—Replying to E. A. S., assuming that the frequency is definitely known to be 60 cycles I would suggest that the rotor be gone over very carefully and all connections at the ends of the rotor coils examined closely, as very often a connection may appear to be good and still have a good deal of the solder melted out causing a high-resistance joint. Several connections with poor joints will cause a motor to act very queerly. After the motor is up to speed, short-circuit the slip rings at the motor by putting a piece of heavy copper wire across the brush holder. After making sure that the rings are well shorted, take another reading of the r.p.m. and note if there is any increase in the speed. If there is an increase look over all connections at the controller and the grid resistance, as this is an indication that the controller is not short-circuiting the rotor properly on the last notch. If there is no increase in speed the trouble no doubt lies in the rotor.

I note that the speed of the motors at full load is 1,185 r.p.m. The synchronous speed would, of course, be 1,200 r.p.m. It appears, therefore, that these motors have very little slip for wound-rotor motors. Ordinarily a wound rotor motor has a slip considerably greater than a squirrel-cage motor. It seems to me that about 1,150 or 1,160 r.p.m. would be a good, full-load speed for a six-pole, 60-cycle, wound-rotor motor. Sometimes the nameplate data becomes disfigured and it is quite difficult to get the numbers correctly. WM. B. CONE.

Electrical Engineer,
Shevlin-Hixon Co.,
Bend, Ore.

Why Do These Motors Stall?

QUESTION.—The motors on two Yale and Towne electric hoists are giving us trouble and I wish someone would tell me how to remedy it. One hoist is of 1-ton capacity and is driven by a 220-volt, three-phase, 60-cycle, six-pole motor. The other hoist is of ½-ton capacity and is also driven by a three-phase, 220-volt, 60-cycle motor. If a load of 200 lb. or more is placed on the hooks the motors will stall, although they seem to run at full speed at no load. This trouble started suddenly. The mechanical part of the hoists has been inspected and appears to be in good condition. Your suggestions will be very welcome.

Iola, Kan. T. R. P.

ANSWER—In reply to T.R.P.'s question, my advice would be first to measure the line voltage, as there is undoubtedly something wrong with the voltage at these motors. I once experienced practically the same trouble, due to the fact that someone had reconnected the motors for a different voltage without changing the nameplate data.

If the line voltage is found to be normal, the best thing to do would be to get an experienced winder to locate the trouble. C. L. UMBERGER.

Chief Electrician,
Premier Coal Co.,
Middlesboro, Ky.

ANSWER—It would appear that the trouble which T.R.P. is having with the two Yale & Towne electric hoist motors is due to poor contact between the rotor bars and rotor end rings. It is quite possible that this trouble may be remedied by welding the bars to the end rings. If this cannot be done, it will undoubtedly be necessary to obtain new rotors. M. E. HALL.

Sales Engineer,
Electro Dynamic Co.,
Bayonne, N. J.

ANSWER—In answer to T.R.P.'s question I would suggest that if he will look closely at the rotors of these motors, he may find small cracks opened up in the laminations; by clamping or pressing these together, and tightening up the rotor rivets, his trouble will disappear.

We have had several of these motors behave this way, and cured the trouble as stated above. Yale & Towne now make a cast rotor for their hoist motors, and I would advise T.R.P. to secure these new rotors, if his hoists are receiving very hard usage.

S. P. CARY.

N. Tonawanda, N. Y.

ANSWER—T.R.P.'s question indicates trouble at the current source; more than likely there is a bad contact on a switch, fuse or the connection to the trolley wire. It does not stand to reason that both motors would develop the same identical trouble at the same time. An open-circuited rotor, or badly worn bearings could cause this trouble, but T.R.P. stated that the mechanical parts of the hoists are in good condition. Another possible cause of trouble is that the motors may not be receiving full voltage.

I remember a very puzzling trouble that developed in a pump motor installation. The motor ran normally when unloaded, but as soon as the load was applied the motor would come to a standstill. The voltage was supposed to be 220, but we found that it really was only 160.

The voltage should be measured while both motors are running with loads.

As another possibility the transformer that furnishes current may be defective. G. H. EMERSON.
Birmingham, Ala.

Moisture-Proofing Treatment for Motors in Pulp Mills

QUESTION.—I wish some of the readers of Industrial Engineer would tell me what method or treatment they use for keeping moisture out of the windings of motors and other electrical equipment which is located in very damp places, particularly in paper pulp mills. I shall be very grateful for any information you can give me.
Temiskaming, Que., Can. J. H. S.

ANSWER—In answer to the question asked by J. H. S., there is no way of keeping water and moisture out of most of the motors because the surrounding air is saturated with moisture. Most of the trouble is caused by water being splashed on the motors when cleaning up. Machine room bosses and superintendents are always willing to co-operate with the electrical department in trying to keep the motors as dry as possible, but the help that does the cleaning usually changes frequently. About the time that you think the cleaning crew is educated to the dangers of getting water on electrical equipment you come in some morning and find a bright young fellow washing spider webs off the ceiling over the motors. He thinks he is doing you a favor by washing off the dust. So it is a question of how to make motor windings resist water and moisture.

After a thorough investigation and study of ways of treating motor windings the following method was adopted. It has been found very satisfactory, as I have not rewound a single motor in the six years since I started this treatment.

When a motor is brought in to be rewound, the type of connection, coil pitch, size of wire and other data are taken when the stator is stripped. In particular we note whether the wires fit very tightly or loosely in the slots, to see if the thickness of the slot insulation can be increased. Whenever possible the coils are made of double-cotton-covered, enameled magnet wire. The thickness of the slot insulation depends on the size of the motors and the amount of room in the slots. Generally one cell of 0.012-in. or 0.016-in. fishpaper is put in the slot next to the iron and reaches up to where the bottom of the wedge will be. One cell of 0.015-in. empire cloth, of the same size, comes next and another cell of 0.007 or 0.009-in. fishpaper is placed inside of the empire cloth cell and extends about ¾ in. above the top of the slots to protect the wires when they are placed in the slot. Another fishpaper cell of the same thickness is placed between the top and bottom sides

of the coils. The coils are taped with one layer of 0.010-in. cotton tape, ½ in. to 1 in. wide, depending on the size of the coils, lapped half-way. Two thicknesses of 0.015-in. empire cloth are placed between phase coils.

When the motor is completely rewound it is given an insulation test of 1,100 volts to ground, with ten 110-volt lamps in series, for about one minute. It is then assembled and run for about an hour or so to make sure that the connections are right and that there are no short-circuited coils. Following this, the motor is taken apart and the stator placed in the oven for four or five hours at a temperature of about 75 deg. C. This heating helps the varnish to penetrate the coils. If they are cold the varnish will be chilled and tend to thicken, thus preventing it from reaching all parts of the coils and sealing up portions of the slots that the coils do not fill up.

By means of a chain block the stator is then lowered upside down into a tank of black, elastic baking varnish, made by the Sterling Varnish Co., until all of the coils are covered. The stator is allowed to remain in the varnish for about two hours, or until all bubbling has ceased. This insures thorough penetration of the coils. The stator is then raised out of the varnish and left hanging until it stops dripping. During this period I keep the varnish tank covered with heavy paper or canvas, with a slot in it large enough to let the chain go through, in order to keep dirt out. Keeping the tank covered also helps to prevent evaporation of the thinner and facilitates draining of the coils, as the varnish is not chilled and thickened before it has a chance to drip off. The stator is then baked at a temperature of about 100 deg. C. for twelve to fifteen hours. We dip and bake stators three times and afterwards give them a brush coat of black, quick air-drying paint.

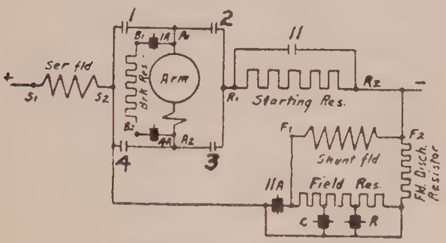
The treatment described above applies to stators where the slots are semi-closed and the coils taped after they are in place. I have so few failures in the larger sizes of motors, in which the coils are made of square wire and taped before winding, that I do not attempt to make the coils. They are purchased from the manufacturer and after the stator is wound it is dipped and baked twice, in order to fill up the slots and insulate the end connections. MARTIN PHILLIPS.

Electrical Superintendent,
Interlake Pulp and Paper Co.,
Appleton, Wis.

Changing Control to Obtain Lower Motor Speed

QUESTION.—The motor on our reversing planer drive is a 10-hp., Westinghouse, frame 90, type SK, shunt-wound motor having a speed range of 250 to 1,000 r.p.m. We have no spare for this motor and when it fails, it is necessary to substitute a 15-hp., 400/1,600-r.p.m.,

type SK Westinghouse, shunt-wound motor. The automatic control on the planer drive is arranged as shown in the accompany diagram. The sequence of operation of the contactors is shown in the table. In this tabulation the number of the contactor is given in the left-hand column, the "Cut" column refers to the cut stroke, the "Return" column refers to the return stroke, and the "Bk." column refers to the dynamic braking applied between reversals. The control is



Sequence of Contactors

Con	Cut		Bk.	Off.	Bk.	Return	
1						O	O
2	O	O					
3						O	O
4	O	O					
11	O						O
1A	O	O	O	O	O		
4A			O	O	O	O	O
11A		O	O	O	O	O	

arranged so that a low speed is used on the cutting stroke and a high speed on the return stroke. These speeds are obtained by proper adjustment of the shunt-field rheostat. When using the 400/1,600-r.p.m., 15-hp. motor, the speed of the return stroke can be properly adjusted, but the cutting stroke is too fast. Full field on the motor gives 400 r.p.m., whereas a speed of approximately 300 r.p.m. is desired. Can readers tell me any way that I can obtain this speed on the 15-hp. motor without rewinding it or changing its fields? Is it possible to obtain satisfactory results with resistance in series or in parallel with the armature? If so, how much resistance should be used, or how should I go about determining the correct amount?

Indiana Harbor, Ind. A. R. D.

ANSWER—In answer to the question asked by A. R. D. the speed of a d.c. shunt motor may be reduced by decreasing the voltage impressed on the armature. The three limitations of speed control, when using resistance in series with the armature, are: (1) Widely varying speeds with changing loads. (2) Inability to reduce the speed with light loads. (3) Inability to secure stable low speeds.

It is impossible to state just how much resistance should be put in series with the armature in order to obtain a definite motor speed unless the amount of motor current is definitely known.

For illustration we can consider a 10-hp., 230-volt, d.c. shunt motor, drawing 36 amp. from the line, re-

quiring a constant torque during the cutting stroke on a planer. If the control wiring is arranged as shown in Fig. 1, so that the resistance is in series with the armature on the cutting stroke, the voltage applied to the armature will be reduced by an amount equal to the voltage drop across the resistor. This drop in voltage is equal to the resistance of the resistor times the current flowing through it or 36 $\times$ 1.5 = 54 volts. The voltage at the armature terminals is 230 — 54, or 176 volts. The speed will decrease in direct proportion to this applied voltage. The speed is then equal to (176 $\div$ 230) $\times$ 400 = 306 r.p.m. If the armature current is only 25 amp., then the voltage drop is 25 $\times$ 1.5 or 37 volts approximately. The voltage at the

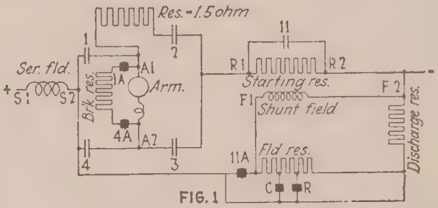


Fig. 1—Reducing the speed of a d.c. shunt-wound motor by inserting resistance in series with the armature.

armature terminals is 230 — 37, or 193 volts. The motor speed now equals (193 $\div$ 230) $\times$ 400 or 335 r.p.m.

In the second case, an armature shunt could be used across the armature as shown in Fig. 2, but this procedure is not recommended by the writer for continuous duty as the current losses in the resistors would be prohibitive. If the shunt resistance method is used, it would be necessary to put a back contact on No. 3 switch and change the brake resistance, because as the shunt resistance is in parallel with it while on the braking point, the resistance path around the armature would be decreased and thus cause a stop which would be much quicker than ordinary. It is not very safe to have this braking current more than 300 per cent of the full-load current. By using the armature shunt, it is possible to reduce the motor speed at all loads, and with light loads a considerable speed reduction results. When the armature shunt is used, it is necessary to put a series resistor between R1 and No. 2 reverse switch, which resistor will be "in" on the cutting stroke.

The speed of the motor, when it is connected as shown in Fig. 2, can be calculated as follows: Armature current = I = 36 amp.; armature volts = E_a = 176 volts; current through shunt = $E_a \div 17.6 = 10$ amp. The drop across the series resistor = 1.17 $(I + (E_a \div 17.6)\ ) = 54$ volts. Now, E_a = 230 —

54 = 176 volts. Current through the series resistor equals 36 + 10 = 46 amp. Then, speed equals (176 ÷ 230) × 400 = 306 r.p.m.

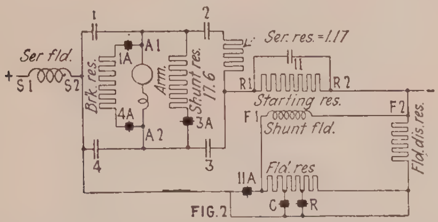


FIG. 2

Fig. 2—In this instance the speed of a d.c. shunt-wound motor is reduced by connecting resistance across the armature.

If A. R. D. desires more information concerning resistance shunts, I would recommend a book entitled "Principles of Electric Motors and Control" by Gordon Fox, published by the McGraw-Hill Book Co.

E. E. Stead.

Foreman, Electric Dept.,
Carnegie Steel Co.,
Mingo Junction, Ohio.

How Does This Motor Start?

QUESTION.—I have a motor made by the General Electric Company that has the following nameplate data: Ser. No. 79,281, type IS, class 4, form A, 60 cycles, 1,800 r.p.m., ½ hp., 110 volts. The nameplate does not say whether the motor is single phase, but as there are only two leads coming out of the machine, I think that it must be a single-phase motor. It has a solid rotor, no starting switch, and no split winding for starting the motor. The winding in the stator is similar to a chain winding. The armature has 36 slots, two of which are empty. The empty slots are spaced seven slots apart. Can some reader tell me how this motor is started from a single-phase power supply?

Oakland, Cal. N. N.

ANSWER—Referring to N. N.'s question, the Type IS motor is a single-phase motor which requires a resistance-reactance starter. Such a starter provides the phase-splitting effect necessary for starting the motor. The resistance-reactance is cut out when the motor is brought up to speed. If possible such a motor should always be started light; that is it should be started up disconnected from the load and the load applied after the motor is up to speed. A suitable starter known as the CR-1027 can be obtained from the manufacturer.

R. F. Emerson.

Industrial Engineering Dept.,
General Electric Co.,

Replacing Motors When Trouble Develops

QUESTION.—When armature or other troubles develop in a motor, should a new armature be put in or other repairs made, right on the job? Or is it better to replace the entire motor with a spare and send the damaged motor to the repair shop? This question has come up several times in our plant and I should like to know the practice followed by other readers.
Pittsburgh, Pa. E. W. D.

ANSWER—In answer to E. W. D.'s question, I would like to state that it depends a great deal on how serious the repair is, on the service which the motor renders, its importance and its size, also, whether the repair shop belongs to the company or to a contractor. It is considered good practice in steel mills and foundries to keep spare motors for important machines, such as cranes and machinery handling hot metal. These spares are kept in the field, where the motor inspector can quickly substitute them for defective motors. In some cases, a whole crane is available as a spare. The reasons for this are obvious: the cost of the motor is insignificant compared with the value of a large ladle of metal or a cupola full of molten pig iron. Also, the labor cost of dropping bottom on a cupola is a large sum compared with the cost of an ordinary motor repair. Other reasons for having spare motors are that motors repaired in the shop are more perfect and reliable, because the shop men have more time and facilities for doing a more thorough job, and they are generally paid a higher salary and are expected to do better work than field repair men.

If the repair man is an expert judge of motor troubles, he can probably make a temporary repair on a motor that has a slight defect, and if a shutdown of an hour or so does not matter, he can put in new bearings, or cut out a coil in a motor of average size. Of course, the necessary repairs could be made under almost any condition and anywhere within reason if the necessary mechanics are available. If the repair shop belongs to the company and the motor is not too large it is probably the best practice to have complete spare motors for the more important drives. The transportation facilities available for taking motors to the repair shop will limit the size of motors that can be handled in the shop.

If a motor is large, say, 500 hp. or over, the cost of a complete spare motor would be prohibitive, even if the plant otherwise had to be shut down a day or so while repairs were being made. Also, in the case of large hoist motors at mines, it would be cheaper to shut down the mines for a week or so to rewind the motor. In this case, especially, the cost of transporting the motor and moving it into and out of the hoisting house

would increase the repair cost. Also, as an illustration, take the case of a large pump motor several thousand feet inside of a mine. In this case, it would be cheaper to rewind the motor right on the job.

GRADY H. EMERSON.

Birmingham, Ala.

Armature Bands Overheat

QUESTION.—Five bands are used on a 220-volt, d.c. armature with which we are having trouble. The armature coils slope very sharply and to prevent the outside bands from slipping off the ends of the armature, the winder soldered copper strips across the bands so as to tie them together. Six 3/8-in. strips were placed parallel to the coils and spaced at equal distances around the armature. The bands as well as the copper strips are well insulated from the armature winding, but the bands and particularly the copper strips become very hot, presumably from some induced current. I would like to know what causes this heating and how it may be prevented. If it is induced current that causes the heating please explain what causes this current. Is there any way in which I can tie these bands together that will not cause the heating referred to?

Oelwein, Ia. L. T. M.

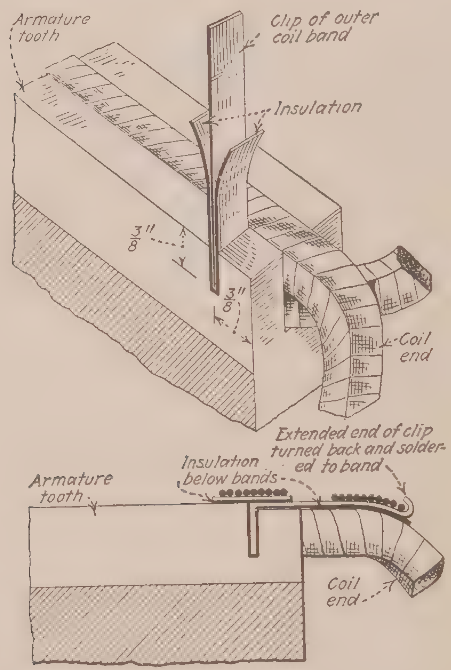
ANSWER—In reply to the question of L. T. M., I am positive that his trouble is due to induced currents in the band connections; he has a squirrel-cage effect from the method of banding that he is using. I have found good results from the following method of fastening end bands so as to prevent them from slipping off the coils, in cases where the coil ends slant to a considerable extent.

After removing the bands from the coil ends, mark off places on the outer edge of the core at points on the teeth where the coil band wire clips should come. These points should be located about 3/8 in. from the outer edge of the tooth. Now in some convenient way, as with a file, cut down the surface of the marked teeth to a depth of 3/8 in. and to a width equal to the thickness of the band wire tie clip and two thicknesses of insulation, as is shown in the top diagram of the accompanying illustration. After this has been done to all of the teeth that were marked, separate the laminations with a small, sharp-pointed chisel in each tooth, as is shown in the illustration.

Then insert in the small slot, one end of the band wire clip with insulation on each side of it, letting the band wire clip stand vertical as shown in the top illustration. Prepare the surface of the coil ends with insulation to receive the band wire. After this is done, bend the clip to a horizontal position. These band wire clips should be made long enough so that when they are bent over with one end insulated in the slot in a tooth, the other end of the clip will ex-

tend about $\frac{1}{4}$ in. beyond the edge of the band wire. After the band wire has been wound on, the extending end of the clip may be turned back over the band wire and soldered in the usual manner, as shown in the bottom illustration.

We are now ready to lay on the special band; that is, the one that is shown at the left in the bottom illus-



Method of anchoring end bands that are inclined to slip off end of armature.—In a tooth, a slot is cut wide enough to take the thickness of the clip and a thickness of insulation on each side of it, as shown in the top illustration. Insulation for the bands is then put on in the regular manner and the clips bent over the insulation, the bands run on, and soldered to the clips, as shown in the bottom illustration.

tration. This is a core band. See that insulation of suitable thickness is placed over the outer end of the core. One edge of this insulation should project about $\frac{1}{4}$ in. beyond the edge of the core so as to allow the band wire to be put on as near the edge of the core as practicable and thereby hold the inserted end of the outside band clip from raising and coming out of the

small slot in the tooth. Careful examination of the bottom illustration will show how the clips holding the band going over the coil ends are anchored in the teeth of the core by the core band. I. F. WISINSKI.
Chicago Elevator & Electric Mach. Co.,
Chicago, Ill.

Proper Babbitt for Armature Bearings

QUESTION.—I would like to learn the experience of other readers as to what kind of bearing metal they find to be most suitable for armature bearings. Is a lead-base babbitt best suited for armature bearings of motors, which are geared direct to the driven machine? With what type of bearing metal do you get the best results on armatures that are direct-connected or belted to the driven machines? There are on the market a great many varieties of bearing metal, including babbitt and various bronze alloys, and I shall appreciate any information that you can give me regarding the selection and application of such metal for use in armature bearings.
Pittsburgh, Pa. H. D.

ANSWER—Answering the question by H. D. I would like to mention the fact that we have adopted the practice of using Parsons White Bronze metal exclusively for all of our motor bearings. There is no question in my mind, however, that almost any good grade of babbitt with a fairly close grain is satisfactory for motor bearings where the drive is direct, providing there is no side thrust due to gears or belts.

In order to prevent wear when motors are belted or geared to the driven machine, there must be an unbroken oil film between the journal and the sleeve at the point where the side thrust occurs. This oil film may become broken down by oil-ways cut at the point of maximum pressure or where a sleeve is too loose, and not parallel with the journal. Other causes might be rough journals, bearings, or both, and in some cases the grade of oil might be too light to stand the pressure. Most of our drives use either gears or belts, which cause considerable side thrust. We use the white bronze because it is harder than ordinary babbitt and has the very desirable feature of polishing the journal, which in turn causes minimum wear on the sleeve.

Our first application of white bronze metal was made about three years ago on a 100-hp. motor that is used on a coal hoist and operates almost 24 hr. a day. It was thought up to this time that hard bronze was the only kind of material which would stand the weight and service. However, we were putting in new bearings about every three weeks and the journals were so rough they had to be redressed or built up each time, a condition which we felt should be remedied. The first set of white bronze bearings operated eight months and the journals looked like polished tool steel. These bearings have been changed two or three times, but the

journals still maintain their polish and so far have required no work on them. We were so well pleased with these results that we commenced using this material in place of babbitt on other motors, with entirely satisfactory results.

We have applications where a cheaper and softer material would serve, however, our motor bearing troubles have declined to such an extent since using this material that it is not worth while stocking another kind. In the end the cost is really no more as the bearings we now use wear longer and have eliminated considerable work on the journals.

If H. D. is having trouble with motor bearings, I suggest that he first check up on the mechanical details, as mentioned above, to be sure that dirt and grit are not allowed to accumulate in the oil wells; then if this does not eliminate the trouble, try the white bronze bearing metal. CHESTER A. WILLIAMS.

Electrical Department,
Providence Gas Co.,
Providence, R. I.

When Should an Armature Be Scrapped Instead of Repaired?

QUESTION.—I shall appreciate it if readers will give me their opinion on the following: If an armature needs new coils, a new commutator and a new shaft, especially if it is of the type that has the laminations stacked on the shaft, is a repair job, with only the laminations for a base, a profitable undertaking? Also, when should the core be junked and new laminations used?
Chicago, Ill. J. E. K.

ANSWER—Answering J. E. K., this is a question that can be best settled by consultation with the manufacturer of that particular motor. If the laminations can be removed from the shaft without tearing them to pieces they can be used again, but even under these circumstances they should be treated, annealed and varnished, which is often done to the iron in stators. Under the present-day methods of treating and handling the iron the junking of cores is not so necessary as heretofore. Continual heating of ordinary iron reduces its permeability and increases the hysteresis loss; while silicon steel has non-aging properties that are not affected by heat, ordinary iron can be improved by annealing and varnishing it.

Junking of cores would, then, be considered in the case of iron that was really damaged beyond redemption, or when there was a question as to the feasibility of installing a new armature rather than repairing and replacing the old one. This would be determined by

the manufacturer's price for a new core, as compared with the cost of repairing the old one.

E. J. Morrissey.

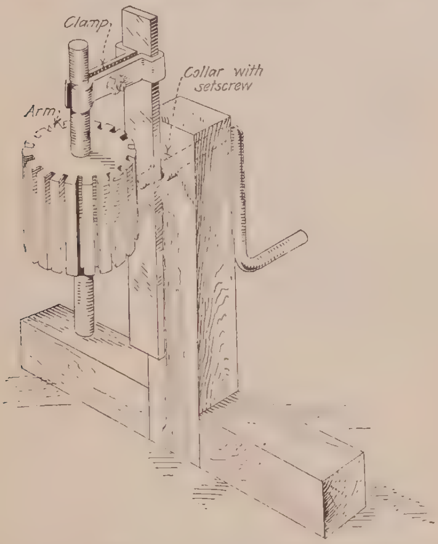
Chief Electrician,
Western United Gas and Electric Co.,
Aurora, Ill.

Simple Device for Winding Small Armatures

QUESTION.—I should like to know if any of our readers can tell me how to construct a simple machine that can be made in the shop and used for rewinding small armatures of the fan and vacuum cleaner types. I should also like to know what other equipment is necessary for the rapid handling of this kind of work. Winding these armatures by hand is too tiresome and slow, and we do not have enough of this work to warrant the purchase of an expensive winding machine.

Brooklyn, N. Y. G. A. L.

ANSWER—G. A. L. can make a simple machine for winding small armatures by following the ideas set forth in the accompanying diagram. Take two maple



An easily-made device that will save much time when winding small armatures.

blocks 2 in. by 2 in. by 12 in., notch out the center of one and the end of the other, and place them together to form a T. This is the support or standard for the device. About 1½ in. from the top of the vertical piece, insert a bronze bushing to take a ½-in. shaft. The crank is made from ½-in. round iron, bent as shown in the diagram, and threaded on one end for a distance

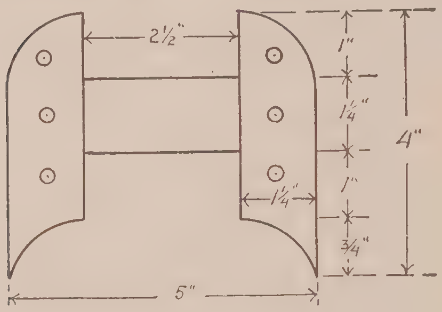
of ½ in. A piece of steel ¼ in. by 1¼ in. by 12 in. is drilled and tapped at the center for the threaded end of the crank.

The clamps for holding the armature to this steel strip are made from strap iron, bent as shown in the accompanying diagram. E. H. WINKLER.

Chief Electrician,
Allen B. Wrisley Co.,
Chicago, Ill.

Winding Data for Growler

QUESTION.—I wish to build a growler of the dimensions shown in the accompanying diagram, for use in testing armatures in our shop. It is my intention to wind this growler with No. 12 double-cotton-covered magnet



wire and I wish some reader would tell me the number of turns of wire to use and also the depth of laminations required. I want to use this growler on 110-volt alternating current. Any information that readers can give me about making up this growler will be greatly appreciated.
Hattiesburg, Miss. J. M. M.

ANSWER—In reply to J. M. M., judging from the size of iron specified and voltage, I assume that this growler is to be used only on small armatures.

I have a growler approximately the same size as the one which J. M. M. shows in his sketch. The only difference is that the height is 5 in. instead of 4 in. and the thickness is 1½ in. instead of 1¼ in. This growler has 160 turns of No. 15 wire and is used on 220 volts. The coil is wound in two sections in order to adapt it for operation on either 110 or 220 volts. At times the two coils are used in parallel on 220 volts, if it is desired to heat a coil up quickly.

If J. M. M. will wind his growler with 70 turns of No. 12 wire, I am sure it will be found quite satisfactory for general use. When using a winding that contains larger wire and less turns, it will be found that when testing armatures having fine wire, the induced

current may be heavy enough to burn the armature winding open before the short can be located.

I also have a larger growler wound with two coils, one on each leg, each wound with 50 turns of two No. 6 wires in hand or a total of 100 turns. The dimensions of this growler are 12 in. in width, corresponding to the 5 in. on the diagram of J. M. M., and 12 in. in height instead of 4 in., with a thickness of 4 in., instead of the $1\frac{1}{4}$ in. shown. When this winding is used across 220 volts to test a 5-hp. armature, it draws 102 amp. from the line. The larger the armature under test, the smaller the amount of current taken from the line.

NICHOLAS J. WEISS.

West New York, N. J.

What Is Wrong with the Method of Rewinding This Armature?

QUESTION.—I have a Willey electric drill, serial No. 20063, 110 volts, a.c. 6 amp., Type 4 U. C. 2, which is manufactured by the James Clarke, Jr., Electric Co., Louisville, Ky. The armature has 17 slots and 32 bars, and is wound with No. 23 cotton-covered enameled wire, using 13 turns per section, with a coil span of 1 to 8, and the leads checking straight out. The armature is hand-wound, left-handed, with the commutator to the right. The only change was that I rewound it right-handed instead of left-handed. I expected that the motor would reverse its direction, which it did. When the drill was connected to the line, both brushes sparked badly, which convinced me that they were off their neutral position. I moved the brush holder to different positions around the commutator, but could not find the neutral point. I took the brush holder head off and checked the leads, which was O.K. Finally the armature was stripped and rewound the same way as before except that I changed the span of the coil from 1 to 8 to 1 to 9. Without moving the brush holders from the position set at the factory, the drill operated perfectly. Why would this armature not operate with the coil span 1 to 8 and wound right-handed? Would winding this armature right-handed instead of left-handed have any effect besides reversing rotation?

Richmond, Va. H. F. S.

ANSWER—In answering the question by H. F. S., I would say that all of our small armatures are machine-wound. It is much easier and better for us, with our equipment, to wind the armatures with the commutator on the right side, the wire being put on left-handed or counter-clockwise. If an armature were rewound right-handed or clockwise and connected up the same as originally, the only change, if everything else about the motor is the same as it was originally, would be to reverse the direction of rotation. To counteract this effect and make the motor operate in the same direction as before it is only necessary to reverse the brush leads or, if the motor is so arranged, the whole brush mechanism could be rocked half-way around and the motor would reverse. According to the information received, this was done and the motor sparked in any position. Such being the case, we are led to believe

that there was something wrong somewhere, aside from the manner in which this armature was rewound.

Stripping the armature and rewinding in slots 1 and 9 instead of 1 and 8, and winding right-handed instead of left-handed, brings the leads out in the same position as if the armature had been wound left-handed, 1-and-8. Since the number of slots in the armature is 17, winding it 1-and-8 brings the leads one slot this side of 17, as 2 times 8 = 16; a span of 1-and-9 brings it one slot on the other side of 17, as 2 times 9 = 18. Winding it right-handed reverses this condition and winding it 1-and-9 reverses it again, which brings it back to the original condition.

The writer is assuming that when the armature was stripped and wound 1-and-9 instead of 1-and-8, it was wound right-handed, the same as when he wound it in the beginning. **J. A. Clark, Jr.**

President,
James Clark Jr. Electric Co.,
Louisville, Ky.

Will Shorting Slip Rings Injure Motor?

QUESTION.—Will shortcircuiting the slip rings on a three-phase, wound-rotor, induction motor damage it? This is likely to happen when the external resistance is entirely cut out of the circuit so as to speed up the motor as much as possible. What takes place when one or more of the brushes do not make contact with the slip rings of such a motor?
Milwaukee, Wis. B. R. B.

ANSWER—In answer to B. R. B.'s question, the motors he mentions are built to run at maximum speed and efficiency with the rotor short-circuited and there is no danger of damage. When the rings are short-circuited these motors have practically the same characteristics as a squirrel-cage motor. In case the resistor and controller become damaged these motors may be short-circuited at the rings and started by the use of a standard compensator of sufficient capacity, although they will not develop very much starting torque when operated in this manner.

If a brush is lifted from a ring while the motor is running the rotor circuit will be opened unless there is a short-circuiting device on the shaft beyond the rings. Opening the rotor circuit will cause the motor to operate single-phase and only one-third of the coils will be active. The rotor will heat badly under these conditions and if run for any length of time the soldered joints would probably come loose and make it necessary to resolder the connections.

Practically all wound rotors of the polphase type have three-phase windings, regardless of whether it is a two- or three-phase machine, and for this reason care must be taken to see that all of the brushes are doing their work, or the machine will overheat. I have had

experience with a great many old, wound-rotor motors using a drum controller for cutting out the resistance. Many of these controllers have insufficient copper contact surface, which resulted in burned-out controllers and damaged rotors. To overcome this difficulty a switch was installed to increase the capacity of the short-circuiting device.

After the controller was put on the last point the switch was closed and made a solid tie across the rotor. Of course, this could not be done with a variable-speed motor, such as B. R. B. is evidently operating, but the brush question is very important and rings and brushes must be kept in first-class condition on wound-rotor motors.

LEE F. DANN.

Chief Electrician,
Donnacona Paper Co., Ltd.,
Donnacona, Que., Can.

Keeping Commutator Bars Straight

QUESTION.—I have considerable trouble in keeping commutator bars true and straight when the commutator is put back on the shaft of the armature after being repaired. The type of armature that I have particular trouble with is a ½-hp., d.c., No. A3, Westinghouse motor. The commutator is held in place by the front and rear V-rings which are locked in place by means of a plate screwed onto the armature shaft. In tightening this plate the armature bars move at an angle or become skewed. Can some reader tell me how to assemble these small commutators in such manner as to prevent them from skewing?

New York, N. Y. B. L. A.

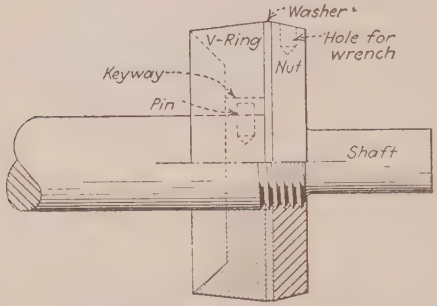
ANSWER—Answering B. L. A.'s question on how to keep commutator bars from twisting while tightening the locking nut, there are several ways to accomplish this. One of the simplest ways is to put a metal washer between the metal V-ring and the nut, and then hold the bars from twisting with a chain pipe wrench while tightening the nut. This method mars the copper segments slightly. Twisted bars may be straightened back into position, even after the nut is tight, by turning them with the chain wrench.

Another way is to drill a hole in the circumference of the metal V-ring and by means of a spanner wrench keep the ring from turning while the nut is being tightened with a second spanner wrench. A third method, that requires more work, is to cut a keyway in the V-ring, and put a pin in the shaft to fit the keyway. The pin should not interfere with the nut, or prevent it from being drawn tight. Some manufacturers use this method of securing the commutator bars in place as standard practice.

Most manufacturers tighten the commutators in a press which clamps the V-ring in place and holds it there, while the nut is tightened. The nut itself is not

used to tighten the bars; it merely holds the pressure obtained by the press. All of the above methods require a suitable wrench for tightening the nut. Some workmen try to set up the nut with a drift, but this only damages the nut and sometimes ruins it. I am taking it for granted that the commutator is only being repaired, and that the bars were originally straight.

In refilling commutators with new bars twisting is



Method of anchoring V-ring to keep it from twisting commutator while tightening commutator nut.—A keyway is cut in the V-ring and a pin is put in the shaft to fit the keyway. The pin should be so located that it will not interfere with the nut when it is pulled tight.

often caused by using cast bars which are not carefully made. Again, the bars may have been stacked improperly in assembling and machined while twisted. Twists of this sort are hard to take out and it is sometimes necessary to change the position of the bars in the commutator, or shim up some of the mica segments at one end. In such cases it is simply a matter of cut-and-try until the desired result is obtained.

C. B. KECK.

Cleveland Heights, Ohio.

Heating of Commutator on Rewound Repulsion-Induction Motor

QUESTION.—I recently rewound a G. E. single-phase ½-hp. four-pole type RI 110-volt repulsion-induction motor and am having trouble with it on account of heating. The commutator seems to heat first and in about two hours the motor gets so hot that you cannot put your hand on it, and it keeps on getting hotter. It does this when running idle. I have tested the commutator, armature, fields, and bearings and they seem to be O. K. The armature is well balanced. I used No. 16 d.c.c. wire in the rotor and main field and No. 18 in the compensating field. I shall appreciate any information regarding the cause and remedy of this condition.

Hubbard, Ore. R. S.

ANSWER—In reply to R. S.'s question, I wish to say

that the trouble he is experiencing with a rewound repulsion-induction motor is probably due to a defective short-circuiting mechanism. Motors of this type use the commutator for starting duty only. When the rotor gets up to a certain speed the commutator is automatically short-circuited, which makes the operation of the machine identical with that of a single-phase, induction motor. When the short-circuiting device is functioning properly, the commutator cannot heat.

L. KONSTAM.

Jones Electrical Repair Service,
New York, N. Y.

ANSWER—I have had considerable experience with type RI motors, so wish to say that this has no short-circuiting device. Two sets of brushes are placed on the commutator, at opposite sides. One set is connected by a jumper, while the other set leads to the compensating field.

This set is, in all probability, the cause of the trouble in the motor. If R. S. will change these back, that is reverse the bursh connections to the compensating field and then adjust the brush setting to the best running position, his troubles will probably be over. This is a common mistake on these motors. If an ammeter is available, place it in the line and determine the load on the motor. Then reverse the compensator field and again read the ammeter. The connection giving the lower reading on the ammeter will be the correct one.

WALTER M. RENNICK.

Buffalo, N. Y.

Method of Removing Cores from Fan Motors

QUESTION.—Will some reader tell me the best method and equipment to use for removing the cores from 10-in., 12-in., and 16-in. Westinghouse fan motors? I find it necessary to remove these cores from the drawn steel housing that encloses the motor so as to be able to make repairs on the connecting wires, which usually burn off very close to the housing. This connection cannot be made on the outside. These field cores fit so closely that it is almost impossible to remove them without injury to the windings with all the methods that I have tried so far.

Madisonville, Ky. E. F. L.

ANSWER—With reference to E. F. L.'s question on removing the cores from Westinghouse metal-frame fans, make a cylinder one and one-half times as long as the core is wide, with the inside diameter slightly larger than the outside diameter of the core. The outside diameter of the cylinder is not important, so long as the wall is as thick as the frame of the fan. Strip the fan down to the core and frame and slip the cylinder over the edge of the core, where the end bell comes off. Grasp the cylinder and core in both hands and

hammer down on a solid block; the core will drop in the cylinder after a few blows.

The core may be put back into the frame by clamping the frame in a large vise and using a smaller cylinder held against the core for driving it into place.

O. B. EVE.

Augusta, Ga.

Burned Spots on Collector Rings

QUESTION.—We are having considerable trouble from burned spots on the collector rings of the field of a 300-kva., three-phase, 240-volt, 25-cycle alternator. These spots are about the size of the brush faces and I am at a loss as to what may cause them. Can any readers tell me causes for this trouble and also suggest remedies for it? I shall be grateful for any information that readers can give me.
Petersburg, Va. J. W.

ANSWER—In reply to J. W., we have had the same kind of trouble on a 250-hp., 220-volt synchronous motor.

The trouble appeared on one ring only, in the form of flat or low spots, about the size of the brushes, and spaced about the same distance apart as the brushes. We first tried to eliminate the spots by sandpapering the ring with a block. This helped a little, but the sparking would stop only for a day or so.

Next we tried putting on new brushes and sanding them in very carefully, but this did no good. We also tried more tension and then less tension on the brushes, but this did not help.

The motor manufacturer's representative said this trouble did not happen often, but when it did it was very hard to correct, and that sometimes the only way to overcome the trouble was to change the polarity of the brushes.

Finally, as a last resort, before changing the polarity of the brushes, I experimented with the angle of the brush-holder: that is, by tipping or swinging the brush-holders so that one brush-holder was nearer the ring than the other holder.

After several trials, I found a position where the sparking stopped entirely and since then, for a period of several months, there has been no more brush trouble. One brush-holder is now about $\frac{1}{16}$ in. nearer the ring than the other holder.

Before finding a remedy to prevent burned spots on the slip rings, a set of brushes would last only a month, while the set of brushes put in soon after the sparking was stopped as yet shows no signs of wear after 6 mo. of service.

I do not know what caused the spots, although there seemed to be low spots on the ring. This ring is now taking a fine polish, all the sparking has stopped, and

the trouble appears to be cured. The trouble did not show up at first, but appeared about 3 mos. after the machine was put in service. The trouble was confined to one ring only. The other ring has given no trouble, and the original brushes on this ring are still in use.

HAROLD H. STEELE.

Marblehead, Mass.

Why Does One Brush Arc on This Commutator?

QUESTION.—I have been testing some series-wound motors rated at 1/60 hp. These run 1,600 r.p.m. under load and take about 0.4 amp. Speed is governed by a three-ball friction governor. With the governor released, the speed is 7,000 r.p.m., at no load. The motor is connected in series with 180 ohms resistance across a 110-volt a.c. line, thereby impressing about 38 volts across the armature.

We have considerable trouble with the brushes arcing and cutting the commutator. This makes the speed very irregular; so we are trying to improve the commutation. Offsetting the brushes so that they do not track increases the trouble. One brush will arc badly, while the other does not and leaves a very little carbon deposit on the commutator.

The commutator has 36 segments and is 1¼ in. in diameter. We have used several grades of brushes, but the best lasted only 368 hr. If anyone can explain this trouble or help me improve the commutation, I shall appreciate it.

Camden, N. J. L. G. J.

ANSWER—With reference to the question asked by L. G. J., I would say that series motors, which do not have a compensating winding, have the brushes shifted from the mechanical neutral against the direction of rotation, thus bringing them to the electrical neutral. To obtain this result the brushes are moved through the angle *r*, as shown in *A* of the accompanying illustration. Due to the armature reaction, the field flux will be stronger (bunched) on one tip of the pole than on the other, as shown.

If the direction of rotation is changed by either reversing the armature or field leads, the field flux will bunch on the other pole tip, thus changing the electrical neutral. Unless the brushes are shifted from the mechanical neutral in the opposite direction, as shown in diagram *B*, the brushes will not be on the electrical neutral. Therefore, sparking will be prevalent, but may be confined to only one brush.

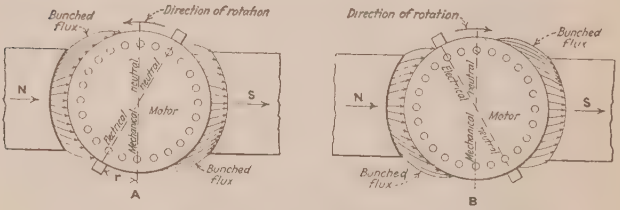
L. G. J.'s trouble may be due to the brush-holder and not to the internal connection of the motor, because the trouble is confined to one brush. Furthermore, the brush life that he is obtaining, is too short. This is an indication of low brush pressure causing the brush and the commutator face to burn away very rapidly. Rapid brush wear cannot be laid to too heavy brush pressure.

If the brush-holder is of the cartridge type, the coil

spring should be carefully inspected. Sometimes it will catch on the inside of the brush-holder and will not apply sufficient pressure to the brush. Also, the spring may be too weak to apply the necessary pressure. In either case the spring tension should be carefully tested by lifting the brush from the commutator face.

Regardless of the type of brush-holder, it would be advisable to inspect the brush carefully to see that it works freely in the box and that the pressure on the brush is sufficient to give a good contact. Very often foreign matter will be found adhering to the inside of the box, thus preventing free travel of the brush.

From the data furnished I am assuming that the brushes are movable. Therefore, another suggestion may throw a little more light on the subject. Due to the fact that sparking is confined to one brush, and if the brush is found to work freely in the box with the proper brush pressure, the next step would be to check the brush spacing. If it is a two-pole motor, the brushes should span one-half of the commutator bars. The brush which does not spark is probably properly



This shows the relation between the electrical and mechanical neutrals for a series motor not having a compensating winding.—Diagram *A* shows the direction in which the brushes must be shifted for counter-clockwise rotation of the motor, while diagram *B* shows the relation for the opposite direction of rotation.

located in the commutating zone, while the brush which sparks may be shifted away from the commutating zone. Therefore, it would be short-circuiting bars that are connected to coils whose potential is not zero, thereby causing the brush to draw an arc when the bars pass out from under it. If this is the case, move the brush-holder holding the brush which does the sparking, in either direction until the sparking decreases.

The explanation of the increase in the sparking with an increase in load is as follows:

(*A*) When the brush tension is low, or if the brush is sticking in the brush box, the increased current through a poor brush contact will increase the sparking. A simple test is to apply additional pressure to the brush. If the sparking stops, the cause is evident.

(*B*) If the brush is off the commutating zone, the increased armature current will cause an increase in the reactance voltage, which will in turn cause an increase in the short-circuited current which must be broken when the commutator bars pass from under the brush.

J. M. ZIMMERMAN.

Renewal Parts Engineer,
Westinghouse Electric & Mfg. Co.,
Pittsburgh, Pa.

Turning Commutators

QUESTION.—I would like some pointers from readers as to the best way of turning commutators in a lathe. What size and shape of cutting tool should I use for the roughing cuts? Will this same tool be satisfactory for the finishing cuts? What is the best cutting speed? Would you recommend using sandpaper to give a final polish to the commutator or do you depend on the lathe tool to give the final polish? I shall appreciate any other details about turning commutators that readers can give me.

Hammond, Ind. H. H.

ANSWER—The selection of a commutator turning tool is of less importance than many other items affecting this line of work, as the choice in most cases depends upon the machinist doing the work for most machinists have their favorite tools for different lines of work irrespective of best practice. The most important part is in setting the tool for a minimum cut with respect to the high points, which are surprisingly high in many cases.

Before any cutting is done it is a pretty good idea to protect the risers and the inside of the armature from the resulting dust and chips. About the simplest manner in which this can be accomplished is to tie a piece of cloth about the commutator as close to the risers as is possible, after which it should be stretched over the top of the coils and tied again, being tightened further after it has been tied in place on top of the coils.

Outside of care in the use of the tool and the taking of medium cuts, there is little to be said regarding the actual turning of the job. With manufacturers this generally resolves itself into two distinct processes, a rough cut followed by certain manufacturing operations and then by the finishing cut.

As to speed I have found that in turning a commutator without removing it from the generator a speed of 100 r.p.m. is satisfactory. In grinding a commutator, however, it is necessary to run it at normal speed with the grinding wheel running in the opposite direction. If the commutator on an adjustable-speed motor is being ground, always grind it at its highest rated speed.

As to the polish I will say that I have seen a number of jobs turned out by using a roughing cut followed by sandpaper for polishing but it is is the practice of a

large manufacturer who is building up an enviable reputation to take two different cuts, slot the commutator and polish while running at the highest rated speed of the armature. This procedure gives an armature as nearly perfect as it can be produced.

However, for ordinary repair work a diamond-pointed tool with No. 00 sandpaper, used with consideration will produce very satisfactory results.

E. J. MORRISSEY.

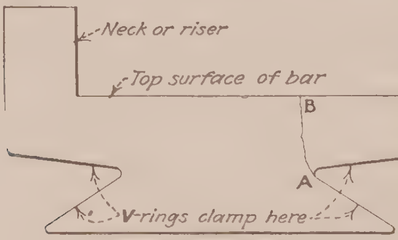
Chief Electrician,
Western United Gas and Electric Co.,
Aurora, Ill.

Is Hard-Drawn or Cast Copper the Better Material for Commutators?

QUESTION.—I would like to find out the difference in operating characteristics, if any, between commutators made from hard-drawn copper and from cast copper. In the advertising literature of many of the large manufacturers of motors and generators, commutators are frequently described as being made of hard-drawn copper. Some repair shops furnish commutators made from cast copper. Which material wears the longer? Which material will polish better under the brushes? Does the sand in the cast copper cause eating away of the mica segments between the bars? Would the use of cast copper segments cause excessive heating of a generator or motor? I shall appreciate any information or comments that readers can give me regarding their experience with either type of material.

Cleveland Heights, Ohio. C. B. K.

ANSWER—Replying to the question by C. B. K., I want to say that my experience over a period of 25



Cast copper segments are subject to breakage at points A-B.

years has proved to me that the best material is the cheapest in the long run. The following statements are made from a careful investigation of commutator material.

There is only one thing that can be truthfully said in favor of a cast-copper commutator, and that is, the price is cheaper than for a hard-drawn copper bar commutator, especially where the commutator has a high

solid riser. A cast-copper commutator will not take on as good a polish as the hard-drawn commutator, will not wear as long, and will "pit" more. Use of cast copper segments causes the mica segments to be eaten away sooner and in many cases will break at the points *A-B* as shown in the accompanying diagram. If the armature has to be rewound, a cast bar with a solid-type riser will break off at the projections next to the wires in the commutator slot more often than a hard-drawn bar. WILLIAM HANKS.
Norton, Va.

What Causes These Brushes to Chatter?

QUESTION.—I have a three-phase 440-volt, 75-hp., slip-ring motor which is giving trouble from chattering of the brushes. Everything that I know of has been tried to prevent this, but without success. The brushes will stop chattering immediately after the slip rings are sanded slightly while the machine is in operation, but after several hours they begin to chatter again. I shall appreciate it very much if some of the readers will tell me how I can overcome this trouble.
Los Angeles, Calif. F. P. B.

ANSWER—Replying to F. P. B., try changing the angle of the brushes. This is often an important factor.

I recall an engine-driven generator I had that would develop brush trouble once in a while, and I found no positive relief for this other than to take the rings off, turn them down and polish at high speed. This would end the trouble until a new brush was needed, and particular care had to be exercised to rid the ring of the slightest sparking or it would immediately develop into serious arcing. I found temporary relief through the use of a little vaseline on this particular machine; this is one way of preventing chatter, and is sometimes sufficient.

Particular care must be exercised in fitting brushes to such temperamental rings; I have found it advantageous to smooth off both the toe and heel of such brushes.

Having brushholders too far removed from the ring is often the cause of chattering and is an inducement in all cases. Brushes that are too loose in their holders, with too little tension, have a tendency to chatter and brushes that are too narrow to carry the current or have a tendency to run off the ring may begin with a sparking that will develop into chattering with bad arcing.

I have found sanding to be of little value in stopping a brush from chattering, and the effect lasts about as long as an application of vaseline. Where vaseline has a noticeable value a change of brushes will generally correct the trouble.

Without making recommendations as to its use or its

value, I have corrected slight chattering with the use of a soft lead pencil while the machine was in operation. It is effective for obvious reasons, but is not recommended as a "cure-all." E. J. MORRISSEY.

Chief Electrician,
Western United Gas and Electric Company,
Aurora, Ill.

Cleaning Wire-Mesh Carbon Brushes

QUESTION.—What is the best way of cleaning wire-mesh carbon brushes that are heavily coated with carbon dust and dirt? Scraping with a knife is slow and not entirely satisfactory. Is there some solution that could be used to clean them? These brushes are used on an old plating generator that is subjected to frequent overloads and the commutator is slightly grooved; so there is considerable sparking. The commutator has been turned down about as much as it can be and as the generator will be replaced before long we do not want to put on a new commutator. However, I must keep the generator in as good condition as possible until it is replaced.
Milwaukee, Wis. A. J. K.

ANSWER—I would suggest that A. J. K. use gasoline to scrub the brushes, with which he is having trouble. A steel bristle brush will clean the pores of the brushes especially near the surface. After the gasoline has dried off, soak them for about 30 min. in a solution composed of two parts of water to one part of ammonia. Then remove them from the solution and put them in clean water, rinsing them thoroughly. If this does not remove all of the grease, the solution can be made stronger. It is well to wear rubber gloves when handling the brushes in this ammonia solution, because the strong solution injures the hands to a certain extent, especially if there are cuts or bruises on one's hands.

I have also used sulphuric acid for cleaning copper brushes and this method could be easily used around a plating establishment, such as is the case with A. J. K. The proper way to proceed with this method is to first dip the brushes in a hot potash solution and then rinse in clear water. The brushes may then be dipped in sulphuric acid until all grease is removed. There is a danger, however, in using this method in that the acid might not be entirely removed from the brushes and when the brushes are put on the commutator they might injure its insulation. Special pains should be taken to remove all of the acid from the brushes.

GRADY H. EMERSON.

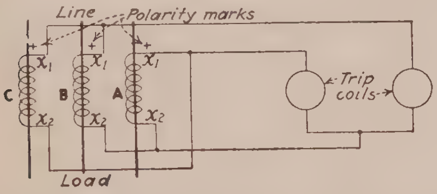
Birmingham, Ala.

Transformers and Electric Controls

Transformers, Meters, Buses; Overload protection, Changing cycle

Is This Relay Connection Scheme Correct?

QUESTION.—I have a 300-hp., three-phase, 60-cycle induction motor that is star-connected to a 4,000-volt, four-wire, three-phase, power supply. Three 75-to-5 ratio current transformers are connected as shown in the diagram to the two trip coils on the circuit breaker for this motor. I believe this connection scheme is incorrect. It looks like a delta connection, but has one current transformer reversed. I think that a "Z" connection of current transformers should



be used, but that is not the case here. Will some reader show me how these current transformers should be connected to insure proper protection of the motor, and also tell me the proper current setting of the trip-coil plunger, so as to trip at 125 per cent load on the motor? Full-load rating of the motor is 39 amp. The trip coils referred to are solenoids located on the faceplate of the circuit breaker and have plungers operating directly on its trip latch.
Waukegan, Ill. S. D. H.

ANSWER—In reply to S. D. H., the following is submitted for his consideration. The scheme shown in his diagram is incorrect, inasmuch as one trip coil is connected to "Z" current and the other to delta current. The "Z" connection should be used throughout, as shown in Fig. 1 of the accompanying diagram.

An explanation of what "Z" current is may help in understanding this connection. The "Z" current flowing through the trip coil is the combination of the two transformer secondary currents of the same polarity. For a balanced load the resultant of these two currents is always equal in value to the current in the third current transformer secondary and is either in phase opposition to it or in phase coincidence. Why this is true can be readily seen from the vector diagram in

Fig. 2. Vectors A, B and C represent currents A, B, and C in the transformer secondaries. These are 120 deg. apart and equal to each other for a balanced load. Assuming the direction of power as indicated, the direction of current in the transformer secondaries will be as indicated by the small arrows. Thus, the combined currents of B and C flow toward the trip coil T_1 and the combined currents of A and B flow away from the trip coil T_2. In other words, the current I_1 through trip coil $T_1 = B + C$ and can be considered to be of positive direction, while the current I_2 through trip coil $T_2 = (—A) + (—B)$ and may be taken as of negative direction.

Referring to Fig. 2, $+B$ and $+C$ added vectorially give resultant $—A$, which is equal to and is in phase opposition to $+A$. Similarly, $—A$ and $—B$ added vectorially will give resultant $+C$.

From the inspection of vector diagram in Fig. 2 it is readily seen that:

$$+B + C = -A$$
$$(-A) + (-B) = +C$$
$$A = B = C$$

The "Z" connections utilize two positive ends and two negative ends of the three transformers, the remaining positive and negative ends are joined together and grounded. These two currents combined give delta current. This may be seen by referring to Fig. 2 from which we see that $I_3 = (+A + (-C) = D = 1.73\ A$.

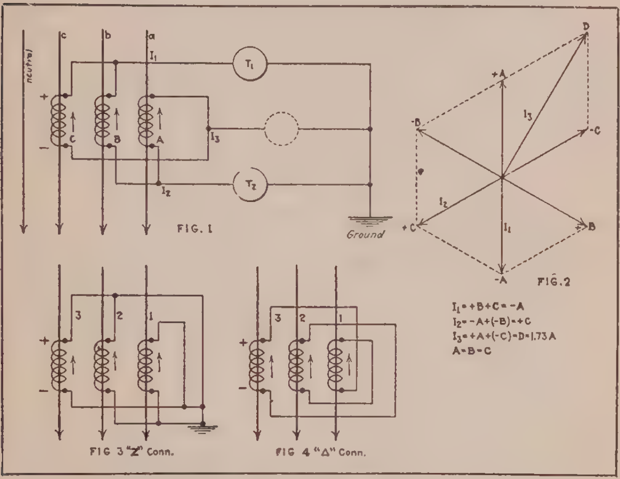
The dotted circle in Fig. 1 gives the location of the trip coil, as shown in the sketch submitted by S. D. H. For obvious reasons this connection is not practical because with a trip coil in this lead, it would receive a current equal to I_3 which is 1.73 times either A, B, or C, with the result that different values of current would be flowing through the trip coils, whereas the "Z" connection gives equal values through both coils.

A simple rule to remember and distinguish the difference between a "Z" and a delta connection is as follows: In the "Z" connection, shown in Fig. 3, the negative end of transformers *1* and *2* are tied together, and the positive end of transformers *2* and *3* are tied together. The two remaining ends, the positive of current transformer *1* and the negative of transformer *3* are tied together and grounded. In the delta connection, the positive end of one transformer is tied to the negative of the adjacent transformer throughout, as in Fig. 4.

It should be remembered also that the instantaneous values are considered and due to the use of the somewhat confusing terms "positive" and "negative" it is suggested that "positive" be thought of as the power side and "negative" as the load side of the current transformer.

It will readily be seen from Fig. 1 that both trip coils

carry "Z" current, which is 5 amp. at full load in the current transformer primary. This connection affords protection against shorts and overloads. Trip coil T_2 will operate on shorts between a and b, or overloads on a and b. Trip coil T_1 will operate on shorts between lines b and c and overloads on b or c. Both trip coils will operate on three-phase shorts or three-phase balanced overloads, or on shorts between lines a and c.



These diagrams show the difference between the "Z" and the delta connections for current transformers.—Fig. 1 shows the correct "Z" connection. Fig. 2 shows vectorially why the currents in the trip coils are always equal to the secondary current from any one transformer. Fig. 4 shows a delta connection, as contrasted with the "Z" connection in Fig. 3.

The trip coil setting can be obtained only by actual calibration. At transformer full load (75 amp. in the primary) both coils will carry 5 amp., while the proper tripping value for 125 per cent load is 6.25 amp. The corresponding value for the coil at motor full load (39 amp.) can be found from the proportion $75 \div 39 = 5 \div x$, x being the normal current through the trip coils at the full load current of the motor. Then, 1.25 x is the tripping value.

Solving the equation we find $x = 2.6$ amp. and $1.25 \times 2.6 = 3.25$ amp., which is the desired value.

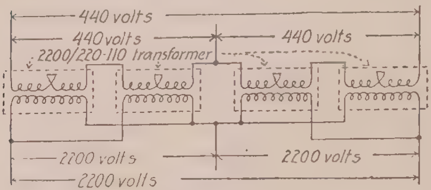
Trip coils as a rule have a range from 5 to about 10 amp. and can be adjusted anywhere between these values by setting the adjusting nut.

The secondary of current transformer should always be grounded. B. J. OPARIN.

Switchboard Section,
Westinghouse Electric & Mfg. Co.,
East Pittsburgh, Pa.

What Is the Capacity of This Transformer Bank?

QUESTION.—I have four 25-kva., 2,200/220/110-volt transformers connected to a three-phase, 2,200-volt, power supply as is shown in the accompanying diagram. The secondary of each transformer is so connected that the two 110-volt windings are in series to supply



220 volts. As can be seen from the diagram, 440-volt, three-phase power is obtained from the secondary of this bank of transformers. I shall greatly appreciate it if some reader will tell me what the capacity of this bank of transformers is with the connection that I am using. I should also like to know the safe secondary line current and also the safe primary line current that these transformers will take with this connection.

Hattiesburg, Miss. J. M. M.

ANSWER—Referring to the query of J. M. M., concerning the connection of four 25-kva. transformers, I would say that the arrangement he shows is practically equivalent to an open-delta connection with the primaries two in parallel and the secondaries two in series. In other words, another set of two transformers similarly connected across the third phase would give a balanced delta connection.

The regulation and efficiency of the open-delta connection are poor, since one phase of the load receives power from two sets of two transformers in series.

It is customary to use the open-delta connection for installations that will grow, to save in first cost. When the load demand increases, the delta is closed by the addition of a third transformer, or set of transformers.

The total capacity of the transformers in an open-delta connection should be 15 per cent greater than the load. This means that the load on an open-delta connected bank of transformers should not exceed 87 per cent of their rating.

Since all coils are in use in the four transformers in this bank, the capacity available is 87 per cent of 100 kva. or 87 kva. Neglecting exciting current, the full-load primary current is equal to $(87 \times 1{,}000) \div (2{,}200 \times 1.73) = 23$ amp., and the full-load secondary current $= (87 \times 1{,}000) \div (440 \times 1.73) = 114$ amp. These calculations are based on the formula, Kva. $= (E \times I \times 1.73) \div 1{,}000$, and $I = (\text{kva.} \times 1{,}000) \div$

$(E \times 1.73)$, in which E = volts, I = amperes, and kva. = kilovolt-amperes. FREDERICK KRUG.

Ass't to President,
Porto Rico R. R., Light and Power Co.,
San Juan, Porto Rico.

Paralleling Open-Delta-Connected Transformer Bank with Closed-Delta Bank

QUESTION.—I would like to obtain the experience of some of our readers in regard to parallel operation of an open-delta-connected bank of transformers with one or more closed-delta-connected banks of transformers. Under what conditions is such operation possible? How does the load divide between the several banks of transformers? How is the capacity affected of both the open-delta bank as well as the closed-delta bank? If we have two banks of closed-delta-connected transformers operating in parallel on both the high- and low-tension sides, will these two banks of transformers continue to operate satisfactorily and divide their load in accordance with their capacity, if one transformer is cut out of one bank so as to make an open delta connection? In this particular case, all of the transformers are of the same size, voltage, ratio, reactance, and were made by the same manufacturer.
Wilmington, Del. H. E. H.

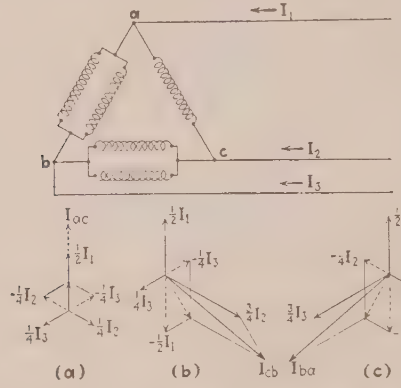
ANSWER—In reply to the question asked by H. E. H., I wish to say that the capacity of a system consisting of a bank of delta-connected transformers in parallel with open-delta-connected transformers will be increased only 33⅓ per cent. This will be apparent from the following discussion.

If we have two transformers connected in open-delta for three-phase operation they will carry only 58 per cent of the kva. transformed, although we have 66⅔ per cent transformer capacity. This can be shown by letting I be the current per phase; then the line current or output current of the delta bank is $\sqrt{3}\,I$, while that of the open-delta bank is I. Hence, the output of the open-delta bank is $I \div \sqrt{3} = 0.58$ of the output of the delta bank. The transformer capacity is not used, due to the phase relationship of the currents and voltages. In the delta connection, considering a balanced load at unity power factor, the current and voltage of each transformer are in phase; but in the open-delta connection the current and voltage of each transformer are out of phase 30 deg., which results in a power factor of 86.6 per cent for the transformers. In order to have the transformers connected in open delta carry full load their combined rating must be 116 per cent of the delta, considering the delta as 100 per cent.

With the open-delta bank connected in parallel with the delta bank, the increased capacity is not 58 per cent, as might be expected, but 33⅓ per cent. The output of this parallel connection is limited by the rating of the delta connection. The diagram shown below will

aid in clarifying the discussion. In this parallel connection, two transformers of the open delta bank are in parallel with two of the delta bank. Hence, the currents in each of the three branches will divide inversely as the respective impedances of these different branches.

Assuming a three-phase balanced load, let I_1, I_2 and I_3 represent the currents between phases *ac*, *cb*, and *ba*, respectively. Considering each phase separately, the



How the current divides in an open-delta-connected bank of transformers when connected in parallel with a closed-delta bank.

currents will divide as follows: Current I_1 breaks up into two paths; $\frac{1}{2}$ I_1 flows through branch *ac*, while $-\frac{1}{2}$ I_1 flows through branches *ab* and *bc*. Current I_2 breaks up into two paths; $\frac{3}{4}$ I_2 flows through branch *cb*, while $\frac{1}{4}$ I_2 flows through branches *ca* and *ab*. Current I_3 breaks up into $\frac{3}{4}$ I_3 which flow through branch *ba*, and $-\frac{1}{4}$ I_3 which flows through branches *bc* and *ca*. Taking the vectorial sum of these currents in each branch, there results,

$$I_{ac} = +\tfrac{1}{2}\, I_1 - \tfrac{1}{4}\, I_2 - \tfrac{1}{4}\, I_3, \text{ as shown at } (a)$$
$$I_{cb} = -\tfrac{1}{2}\, I_1 + \tfrac{3}{4}\, I_2 - \tfrac{1}{4}\, I_3 \text{ as shown at } (b)$$
$$I_{ba} = -\tfrac{1}{2}\, I_1 - \tfrac{1}{4}\, I_2 + \tfrac{3}{4}\, I_3, \text{ as shown at } (c)$$

It must be remembered that the currents in each branch are displaced 120 deg. and that the indicated signs are vectorial signs; hence, negative vectors are reversed and added to positive vectors.

To illustrate the preceding equations, let us assume a three-phase current of 100 amp. in the line; then substituting in the equations, we have

$$I_{ac} = +50 - 25 - 25 = 50 + 25 = 75$$
$$I_{cb} = -50 - 75 - 25 = 75 + 40 = 115$$
$$I_{ba} = -50 - 25 + 75 = 75 + 40 = 115$$

From this result it is obvious that the winding *ac* which carries 75 amp., limits the output of the system.

If the delta bank were used alone, it could carry only 75 amp. However, with an open-delta bank connected in parallel with the delta bank, a 100-amp. load can be carried, which is an increase of 25 amp. or 33⅓ per cent.

FREDERICK NIMMCKE.

Grounding a Delta-Connected Transformer Bank

QUESTION.—I should like to know some of the standard or practical methods of grounding a delta-delta connected bank of transformers. We have a transformer bank consisting of three single-phase, 13,200/440-volt transformers, which are delta connected on both the high- and low-tension sides. Now I get a reading of about 100 volts from each 440-volt bus to ground. Consequently, I am planning to ground the low-tension side of the transformer bank. Can some reader tell me to what part of the low-tension delta I should connect my ground or what reactors or other devices I must use to obtain my ground connection?

Omaha, Neb. G. C. B.

ANSWER—In reply to the question asked by G. C. B., one standard method of grounding is to connect the middle point of one of the transformers to ground, as shown in Fig. 1. If there are no middle taps on the transformers, then one corner of the delta, that is, one line wire, must be grounded.

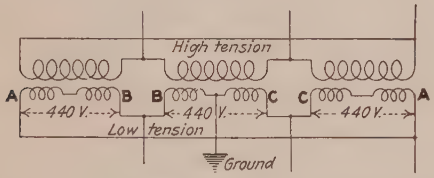


Fig. 1.—The middle tap of one transformer in a delta-connected bank may be used as the grounding point.

When grounding a transformer bank, as shown in Fig. 1, it should be noted that the voltage from two of the line wires to ground will be 220 volts and from the remaining line wire to ground will be 381 volts. This is clearly illustrated in the left-hand diagram shown in Fig. 2. In this diagram the middle tap of transformer BC is grounded. Hence the potential from point B or C to ground will be 220 volts, while the potential of A will be 381 volts above ground potential. The right-hand diagram in Fig. 2 illustrates the conditions that exist when the delta is not grounded. In this case the stress to ground is the same from each line wire, being 254 volts. Inasmuch as the insulation of one wire is under 381-volt strain to ground, more motor insulation failures are likely to occur with a grounded secondary installation of this kind.

If other banks of transformers are operated in parallel with the grounded bank, care must be taken to see that all banks are grounded in the same place; that is, if transformer *BC* is grounded in the first installation, all succeeding installations must likewise have

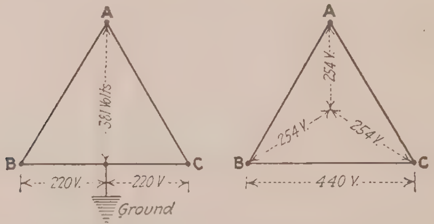


Fig. 2—Grounding of the middle point of a transformer gives an unequal voltage stress to ground on the three line wires.—As shown at the left, lines *B* and *C* have a potential to ground of 220 volts, while line *A* has a potential of 381 volts to ground. Voltage stresses to ground on an ungrounded delta-connected bank are equal, as is shown in diagram at right.

the transformer *BC* grounded. This is to prevent short-circuiting part of a transformer winding.

One advantage of the grounded secondary system is that it prevents trouble from capacity effects. A person coming in contact with a wire of an ungrounded system may receive a shock, due to the capacity effect between the high- and low-tension windings of the transformer. The higher the primary voltage of the transformer and the larger the system, the greater will be the condenser or capacity effect.

Installation of reactors or other devices in the ground circuit is not to be recommended as this may interfere with the correct operation of protective devices.

L. P. STAUBITZ.

Chief Electrician,
LaClede Steel Co.,
Alton, Ill.

Are Transformer Laminations Injured by Burning Off Oil and Insulating Compounds?

QUESTION.—I will appreciate it if some readers can give me the following information: Does heating transformer laminations to remove the insulating compound and oil injure them? Is it standard shop practice to do this? How much will the iron loss be increased, if any, by this procedure? If the laminations are japanned after burning off the oil and compounds, will this cut down the core loss? Will an oxide form on the iron, during the heating, which will cut down the core loss? How hot may the iron be heated without injuring it?
Santa Ana, Cal. C. C. B.

ANSWER—Replying to the question of C. C. B., it

cannot be positively stated that burning off oil and insulating compound from laminations will cause serious heating. If the insulating compound, which is usually some form of japan, has been burned off the safest thing to do would be to obtain new laminations. If this is too expensive or impossible the laminations should again be japanned. It is impossible, except by actual test, to tell whether the core loss is increased.

Whether this method of handling laminations should be followed or not must be left to the judgment and experience of the man in charge. While the oxide that is formed during the heating may help as an insulator, it cannot be depended upon the same as a uniform coating of japan. There may also be a change in the actual space required in stacking, due to the greater thickness of the laminations.

Heating iron to a temperature approaching a red heat causes the formation of a coating of iron oxide on the surface, thus increasing the thickness.

The writer knows of a number of jobs, where the japan and oil were burned off and the laminations re-stacked without any other treatment. While most of the machines seemed to operate satisfactorily, some trouble occurred which might readily have been attributed to the treatment of the iron. In the case of one large transformer a great deal of trouble in re-stacking was caused by burning off the oil and japan. Possibly too high a temperature was used for this purpose.

C. OTTO VON DANNENBERG.

Electrical Division,
General Engineering and Management Corp.,
New York, N. Y.

Does Change in Transformer Connections Affect Rated Capacity?

QUESTION.—I have three 100-kva., single-phase, 2,200-110-volt transformers, which I intend to connect in a bank to deliver three-phase power at 110 volts. If a delta-delta connection is used to connect the bank, what power capacity can I get from the transformers? Will I get the same power capacity from a star-star connection? I shall appreciate any information that readers can give me on this question.
Telluride, Colo. T. H. C.

ANSWER—In answer to T. H. C., changes in connections of the three 100-kva., single-phase, 2,200/110-volt transformers, would not alter the capacity of the transformers as long as they are operated at the voltage for which they are designed. The 220-volt primary coils of a 100-kva. transformer will carry 45.5 amp. at full load. With the three transformers connected delta-delta on a 2,200-volt system, the primary coils of each transformer will be carrying 45.5 amp., the line current will be 78 amp. or 1.73 times the current in

the primary coils, and the output of the bank of three transformers will be 300 kva. If these transformers were connected star-star to a 2,200-volt system, the voltage across the primary side of each transformer would be 2,200 ÷ 1.73 or 1,271 volts. With each transformer carrying full-load current of 45.5 amp. the output of each transformer would be 1.271 × 45.5 = 58 kva., and the capacity of the bank would be only 3 × 58 = 174 kva.

The usual conditions under which 2,200/110-volt transformers are connected in star, would be with a line voltage of 3,800 volts and the transformers connected star-delta. In this case each transformer would have 2,200 volts across its primary and with 45.5 amp. primary current would be carrying a load of 2,200 × 45.5 = 100 kva. The output of the bank would be 3 × 100 = 300 kva., and with the secondary side connected in delta, the secondary voltage would be 110 volts, since the transformer voltage ratio is 2,200/110 volts.

The use of 2,200/110-volt transformers in this way has usually come about through an increase in line voltage from 2,200 to 3,800 volts. This gives the utility company increased line capacity at small expense, since the same transformers can be used. The generators may be so arranged that the ends of each phase winding are brought out giving six terminals; hence the windings may be connected in either delta or star. If in delta, the terminal voltage will be 2,200 volts; if in star, 3,800 volts. If the utility company's lines are operating at 2,200 volts, three-phase, three-wire, and it is desired to increase the line voltage to 3,800 volts, the generator windings are reconnected in star and usually the common point of the star is grounded and is also connected to a fourth wire, giving a three-phase, four-wire system. The voltage between the first three wires is then 3,800 volts and the voltage between any one of these and the fourth wire is 2,200 volts. The primary sides of all of the transformer banks are then reconnected in star and will operate with a line voltage of 3,800 volts and will have 2,200 volts impressed across the primary of each transformer. With the secondary connected in delta, 110 secondary volts will be obtained. The fourth wire with any one of the others provides a 2,200-volt primary supply for the single-phase lighting transformers, which can be balanced across the three phases.

If T. H. C.'s primary voltage is 2,200 volts, his transformers should be connected, delta-delta to give 300 kva. with a secondary voltage of 110 volts. The transformers should be connected star-delta if his line voltage is 3,800 volts and should not be connected star-star in any case if it is desired to operate them at their rated capacity of 300 kva., with a secondary voltage of

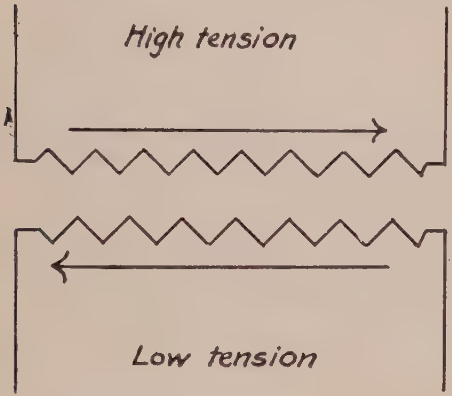
110 volts. If the star-star connection were used under these conditions, the secondary voltage would be $110 \times 1.73 = 190$ volts, which is a higher secondary voltage than would be desired for a 110-volt secondary circuit.

L. T. JOHNSON.

East Cleveland, Ohio.

Polarity of Transformer

QUESTION.—I am somewhat confused as to the relationship between the primary and secondary voltages for transformers of different polarities. Assume a transformer having primary and secondary voltages in



the winding as shown by the arrows in the diagram. Can some reader tell me whether this transformer has additive or subtractive polarity, and why?

Chicago, Ill. G. A. V.

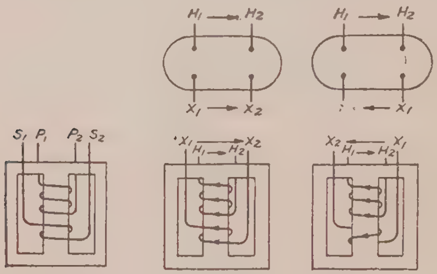
ANSWER—In reply to the question asked by G. A. V., the transformer in question is of additive polarity. In Vol. 23, No. 5 of the *General Electric Review*, A. Boyajian gives a very thorough discussion of this question. I will try to prove my answer to G. A. V.'s question with an abstract of Mr. Boyajian's discussion.

In Fig. 1 of the accompanying diagram is represented a simple, single-phase transformer. It is of interest to consider the relative direction of the windings and voltages. It will be observed that coil S_1S_2 is wound in the same direction as P_1P_2, assuming that the first coil starts from the S_1 and the second from the P_1 leads. On the other hand, the S_1S_2 coil is wound in the opposite direction to P_1P_2, if we assume that the first starts from S_1 and the second from P_2. We conclude, then, that whether two coils are to be considered as wound in the same direction, or in opposite directions, depends

on which terminals are considered as the start and which the finish. Thus, in Fig. 1, coils S_1S_2 and P_1P_2 are in the same direction, while coils S_1S_2 and P_2P_1 are in opposite directions.

Since the primary and secondary induced voltages are induced by the same flux, they must be in the same direction in each turn as is shown in Figs. 2 and 3.

However, whether they will appear in the same or opposite direction as viewed from the terminals depends on the relative directions of the windings. Thus, in Fig. 2 voltages H_1H_2 and X_1X_2 are in the same direc-



Figs. 1, 2 and 3—The voltages induced in the individual turns of the primary and secondary windings are in phase, even though the windings are wound in opposite directions.

tion and in Fig. 3 voltages H_1H_2 and X_2X_1 have opposite directions. Also, in Fig. 2, voltages H_1H_2 and X_2X_1 are in the opposite directions and in Fig. 3 voltages H_1H_2 and X_1X_2 are in the same direction.

When the induced voltages of the high- and low-voltage sides are in opposite directions as in Fig. 3, the polarity is said to be additive; and when the induced voltages are in the same direction as shown in Fig. 2, the polarity is said to be subtractive. The reason for this nomenclature will be evident from the following:

Referring to Fig. 2, if we connect a high-voltage lead to the adjacent low-voltage lead, for instance H_2 to X_2, and excite the transformer on either side, the voltage across the leads, H_1 to X_1 will be the difference between the voltages of the two sides. Following the voltage from X_1 to X_2, thence to H_2 and then to H_1 it is evident that the voltage H_2H_1 will oppose the voltage X_1X_2, and the polarity is subtractive.

Referring to Fig. 3, which shows primary and secondary induced voltages in opposite directions, if we connect an H lead to the adjacent X lead, for instance, H_1 to X_2 and excite the transformer, the voltage across the other leads, that is, H_2 to X_1 will be the sum of the primary and secondary voltages, for reasons explained

in the previous paragraphs. Hence, the polarity is additive.

FRED W. PAFFEN.

Engineering Dept.,
American Cellulose & Chemical Mfg. Co.,
Cumberland, Md.

Transformer Draws Heavy No-load Current

QUESTION.—We have a 75-kva., 25-cycle, single-phase, 2,200/220/110-volt lighting transformer which draws an excessive no-load current. The primary current with all secondary load disconnected is about 11.5 amp. at 2,200 volts. The secondary voltage is normal at 0, ¼, ½, ¾ and full load. The temperature of the oil is normal. The insulation resistance between windings and between windings and ground is over 50 megohms. What is the cause for this high no-load current?

Hamilton, Ont., Can. J. F. M.

ANSWER—Referring to the question by J. F. M. in a recent issue, he states that the secondary voltage is normal from zero load to full load, and that the temperature of the oil is normal. Assuming that the frequency of the supply is not lower than normal the only apparent reasons for a high exciting (no-load) current would be some looseness or poor contact in the magnetic circuit, poor quality iron in the core, or some inherent defect in design of the transformer. With the modern transformer, the fault or trouble seems more likely to be found in the core through poor iron or construction, rather than in actual design.

C. OTTO VON DANNENBERG.

Electrical Division,
General Engineering and Management Corp.,
New York, N. Y.

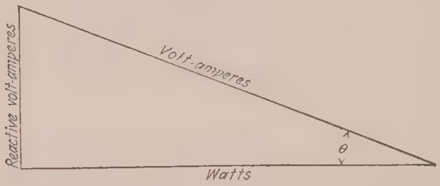
Function of a Reactive Volt-Ampere Indicator

QUESTION.—We recently ordered from a meter manufacturer a three-phase, switchboard-type watt-meter. When the meter arrived at the plant it was marked, reactive volt-ampere indicator, instead of watt-meter. I wish some of the readers of this column would explain the difference between these two meters and tell me the application and use of the reactive volt-ampere meter. Any details regarding the use of this meter will be very helpful.

Detroit, Mich. R. J. B.

ANSWER—Referring to R.J.B.'s question, the function of a reactive volt-ampere meter is as follows: A reactive volt-ampere meter is a wattmeter so connected in the external circuit that it indicates the component of the total kva. which supplies the magnetizing power of the load, while a wattmeter indicates the power component. This meter measures the so-called idle or reactive component, which is at an angle of 90 deg. to the useful, or power component, which is known as the watt component.

The true relationship of the total load with its two components is shown by vectors in the accompanying diagram. In this vector diagram, it can be seen that when both types of meters are used, the total kva. load of the system can be found by extracting the square root of the sum of the squares of the two readings. When a reactive volt-ampere meter is used instead of a wattmeter, and it is desired to determine the power factor of the load, the following formula is used: reactive kva $\div$ (volts $\times$ amp. $\times$ $\sqrt{3}$) $=\sin\theta$, in which



This diagram shows the relations existing between reactive kva., kw., and kva. and also shows the angle by means of which the power factor is computed.

θ, is the angle of phase displacement, or the angle between the total volt-amperes and the true power component in watts as shown. The cosine of this angle is the power factor of the load.

The power factor of the load can also be determined from the wattmeter and kva. meter readings by the following formula: $\tan\theta$ = watts $\div$ reactive kva., in which θ is the angle shown in the accompanying diagram. Cos θ equals the required power factor. For instance, assume that a wattmeter indicates 1,000 kw. while the reactive volt-ampere meter indicates 500 kva. The power factor of the load is then equal to the cosine of the angle whose tangent equals 500 $\div$ 1,000 $=$ 0.5. The angle of which 0.5 is the tangent is 26 deg., 35 min. and the cosine of 26 deg., 35 min. $=$ 0.89 or 89 per cent power factor.

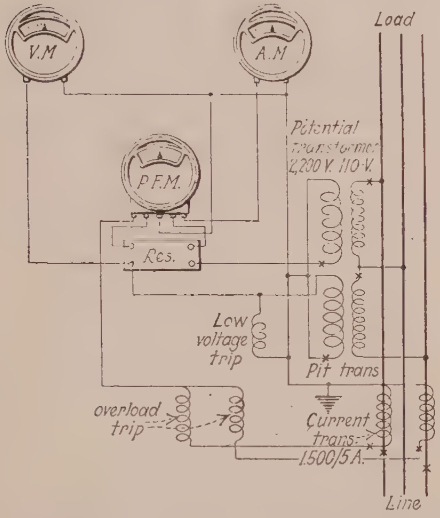
The internal connections of the two instruments are identical, the difference being in the external connections. A wattmeter, to indicate reactive volt-amperes, must have the potential circuit excitation shifted 90 deg., since the readings of these instruments are always exactly 90 deg. apart, as shown in the diagram. This shifting is done by a special tap transformer or by inserting a special external reactance in one of the potential leads. The connections of two graphic meters giving the above indications were shown in an article by the writer, published in the July, 1925, issue.

H. E. STAFFORD.

Electrical Engineer,
Provincial Paper Mills Ltd.,
Port Arthur, Ont., Can.

Why Do These Meters Not Register?

QUESTION.—We have a Weston power factor meter, Model 356, serial No. 790, and a Weston ammeter, Model 156, serial No. 43008, mounted on a switchboard manufactured by the Condit Manufacturing Co. and connected as shown in the diagram. The connections from the switchboard to the current and potential transformers were made by my workmen. The polarity marks on

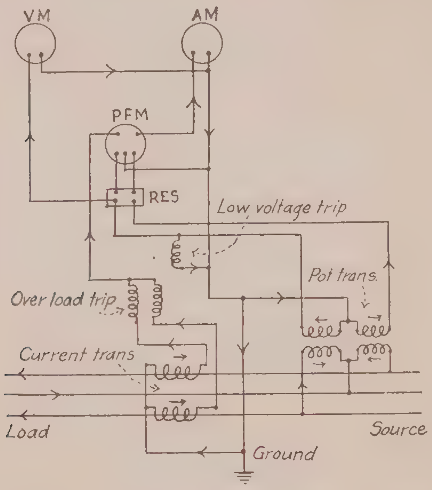


the transformers are as indicated. The ammeter reads zero when power is flowing through the switchboard. The power factor meter likewise remains in the same position as when power is off the board. Is the connection scheme shown in the accompanying drawing correct? If so, what do you think is wrong and what tests should I make to locate the trouble?
Sharon, Pa. C. F. C.

ANSWER—If C. F. C. will trace his current in the common return wire, he will find that he has the current traveling in at his current transformers and in the opposite direction, that is out, from his potential transformers. This will not work, as the meters will act as though connected as a shunt on one wire; that is, the current is trying to go out at both terminals at the voltmeter and trying to go in at both terminals at the ammeter. In fact, the current is not flowing at all. If he will connect them as shown in the accompanying diagram his meters will all register. Should the power factor meter read lead instead of lag, he can interchange two potential transformer lead wires, and if the pointer goes off the scale in the lead direction he

should change both the potential lead wires and also the current wires.

He should always connect his potential transformer behind his current transformer, as shown in the dia-



Connections for power factor meter, ammeter, voltmeter and relays.

gram, when connecting switchboard instruments so that the ammeter and wattmeter will not register the current used by the potential transformer, as this load should never be registered on the meters.

WILLIAM P. AMANNS.

Chief Electrician,
Knoxville Iron Co.,
Knoxville, Tenn.

Connecting Watt-hour Meter to Three-Wire Circuit

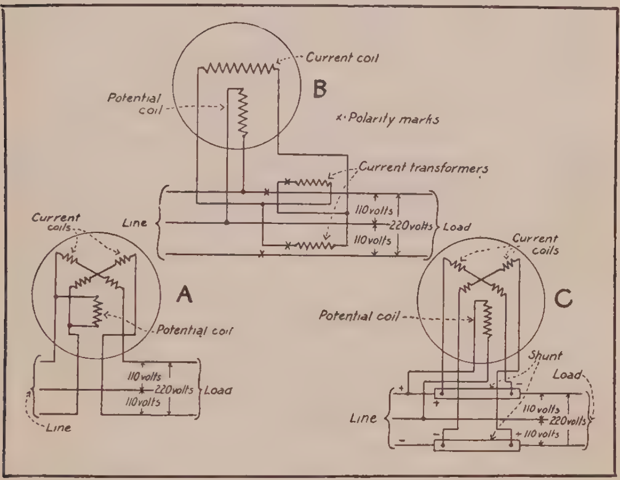
QUESTION.—Will some reader please give me a diagram and explanation of how to connect a watt-hour meter to an Edison three-wire circuit? Is a special type of meter required? Why?

Bellaire, Ohio. J. R. B.

ANSWER—In J. R. B.'s question in a recent issue, he does not state whether the meter is to be used on direct or alternating current, nor whether shunts or instrument transformers will be employed. However, in any case it is necessary to employ either a special meter or an ordinary two-wire meter with a special hook-up of instrument transformers, to secure correct metering.

Power in a three-wire Edison system is the sum of the kilowatts in each leg of the circuit. It is also to be noted that the current in the neutral is the difference between the currents in the two legs, and the direction of that current depends upon the direction of the current in the outer wire carrying the greater current.

In case an ordinary two-wire, single-phase meter were used (with one potential coil and one current coil), power would be measured in that side of the circuit in which the current coil was connected. If a current coil of a meter is placed in one leg with its potential coil across the two outer legs, correct results would



Connections for metering Edison three-wire circuit by means of A, special meter; B, two-wire meter with special connection of current transformers, and, C, direct current meter with shunts.

be secured only when the circuits were absolutely balanced, which is an infrequent condition in three-wire circuits. If the current coil were connected in the outer wire carrying the larger current, the meter would total too many kilowatt-hours while if it were connected in the other leg of the circuit it would not record the entire consumption. In case a two-wire meter were used with the potential coil connected across the neutral and an outer wire, the meter would in no case be correct and would meter only half the energy consumed were the load exactly balanced.

It may be seen from the above that it would be possible to meter a three-wire Edison circuit with either

two two-wire meters with potential coils connected across the neutral and respective outer legs, or by the use of a special meter with one potential coil and two current coils acting on the same disc. This is the type of meter used in such circuits when a self-contained meter is used and its hook-up is shown in *A* of the diagram. In this three-wire meter each current coil in conjunction with the potential coil exerts a torque on the meter disc proportional to the kilowatt demand in the leg of the circuit in which the current coil is connected. The coils are so connected that the torque from each current coil turns the disc in a forward direction and each coil acts independently of the other. In case current transformers are used in an alternating-current circuit, a two-wire meter may be used providing the meter and transformers are connected as shown in *B*. If standard current transformers and an ordinary 5-amp., 110-volt, two-wire meter are used with the register correct for the meter when used as a self-contained, 5-amp. meter, the readings on the register should be multiplied by a constant equal to (2 × current transformer ratio). A much better plan would be to advise the manufacturer of the meter of the size, type, and serial number of the meter used, as well as the current transformer ratio and connections. The manufacturer could then furnish a direct-reading register. In case the meter is used on a three-wire, direct-current circuit with shunts, a hook-up is given in *C*. Either a special register or a special register constant should be used in this case. An explanation of how to determine the register constant would be rather long and complicated, without more specific details.

details.

HERBERT KING.

Toronto, Ohio.

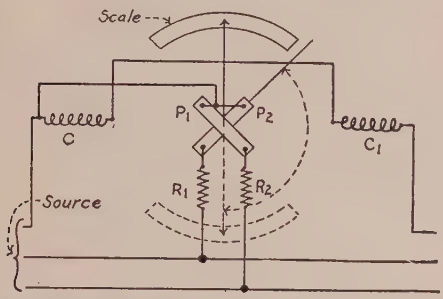
Connecting Three-Phase Power Factor Meter

QUESTION.—I should like to obtain the following information from some of the readers of Industrial Engineer. (1) How may a three-phase power factor meter of General Electric make, be connected up for correct operation on either leading or lagging current when all of the polarity marks have been obliterated? (2) How may the circuits of the above meter be tested for continuity and zero setting of the pointer when it has been moved on the revolving shaft which supports it? (3) What would cause a shunt generator driven by an induction motor to build up slowly at the commutator and develop destructive arcing at the brushes after the load has been removed? What would be the remedy for such a condition? The armature is a single, parallel winding.

Saskatoon, Sask., Can. F. N. G.

ANSWER—In reply to the question by F. N. G., the accompanying sketch shows the connection for a three phase instrument used on a balanced system.

C and C_1 are current coils in series on one leg of the system. P_1 and P_2 are potential coils connected across the other two legs of the line through the non-inductive



Internal and external connections of three-phase power factor meter.

resistance R_1 and R_2. In making the connections and checking for their correctness, the power factor must be known. If the needle drops to the bottom or dotted line scale, reverse the series connection. If the power factor is unity and the pointer takes a position to the right or to the left of center, reverse the potential leads. The circuits of the instrument may be tested for continuity with a lamp in series on a 110-volt circuit. If the pointer is loose or has been moved, connect the instrument to a circuit of 100 per cent power factor and place the pointer opposite the unity mark on the scale.

The character and range of the scale can also be changed by varying the angle between the potential coils.

With regard to the trouble which you are experiencing with a d.c. generator, the brushes are probably not set correctly in relation to the neutral point. Try changing the brushes either ahead or back a little at a time and see if it helps the sparking.

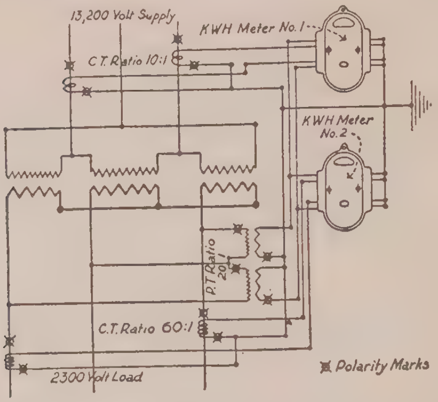
LEE F. DANN.

Chief Electrician,
Donnacona Paper Co., Ltd.,
Donnacona, Que., Can.

Will These Watt-hour Meters Read Alike?

QUESTION.—The diagram shows a proposed method of connecting watt-hour meters on the primary and secondary sides of a bank of transformers connected delta-star. As shown, the meter measuring the high-tension power receives its current from current transformers in the lines supplying the delta-connected primary, while the potential supplied is the low-tension line voltage. The low-tension watt-hour meter is connected in the usual manner. I should like to know

if this connection for No. 1 meter will work satisfactorily. Also, if we disregard the copper and iron losses in the transformers will there be any difference in the records of the meters at unity power factor,



and at 85 per cent, 70 per cent and 45 per cent lagging power factor, assuming that the load is always balanced?

Longview, Wash. J. C. R. C.

ANSWER—Answering J. C. R. C., the two meters connected as shown will not register the same.

Meter No. 2 will register correctly under all conditions of power factor. Meter No. 1 will vary in its registration depending upon the power factor, since it is incorrectly arranged. The reason for its incorrect registration is the angular relation of the current and voltage introduced through the star-delta connection.

At 100 per cent power factor, meter No. 1 has one element in which the current is in phase with its voltage, while in the other element the current lags 60 deg. behind its voltage. In the case of meter No. 2, the current in one element leads its voltage by 30 deg., and the other lags behind 30 deg.

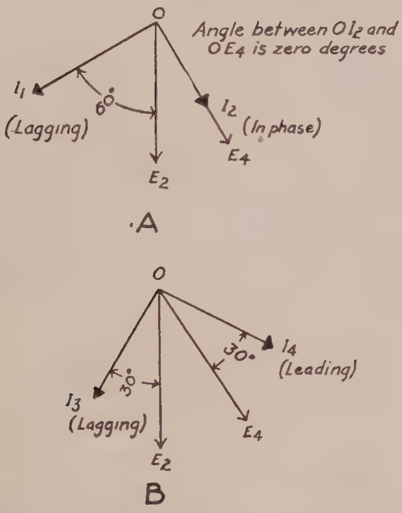
The relations of current to voltage in meter No. 1 are correct for the registration of the total energy used, and are shown vectorially for 100 per cent power factor in diagrams *A* and *B*. In diagram *A*, OI_1 and OI_2 represent currents in the 13,200-volt line; OE_2 and OE_4 represent the voltages betwen the 2,300-volt lines.

The approximate relations of the registration of the two meters for the power factors listed are as follows:

Power Factor	Meter No. 1	Meter No. 2	Ratio of 1÷2
100	1.5	1.732	0.886
85	0.8185	1.472	0.556
70	0.4308	1.2084	0.356
45	—0.0987	0.7792	—0.127

This tabulation assumes of course that the load is always balanced. It should be noted that at 45 per cent power factor, meter No. 1 will run backward. Referring to the diagram, only the actual vectors which are involved, have been given. This was done to avoid confusion and to aid in making the relations clearly and easily understood.

As previously stated, the relations shown in the diagram are for 100 per cent power factor. For all lagging power factors, the current vectors will swing in a clockwise direction. For instance, at 45 per cent power factor, the angle between E_2 and I_1 will become 123.3 deg., and 63.3 deg. between E_4 and I_2.



Vectorial relations of current and voltage at 100 per cent power factor in meter No. 1, shown at A, and in meter No. 2, shown at B.

It is also assumed that both meters are arranged for direct reading without the use of a constant, or in other words, have the correct gear ratio to suit the current and voltage transformer ratios.

This method of metering has been used but usually only with delta-delta connected banks, making allowance in meter No. 1 for the transformer losses by adjustment or other compensation. The correct solution in this particular case would be to install 13,200-volt meter voltage transformers.

C. Otto von Dannenberg.

Electrical Division,
General Engineering and Management Corp.,
New York, N. Y.

Number of Poles in Stator Determined by Use of Compass

QUESTION.—(1) Can some reader give me a simple method of determining the number of poles in two- and three-phase stators when the nameplate is missing? That is, can I pass direct current from dry cells or other source through the winding and use a compass to locate the poles? Or will it be necessary to trace out the winding? How should I go about tracing out a winding to find the number of poles? (2) Why does the terminal on the positive pole of a storage battery corrode, while the negative terminal does not? I shall appreciate your help.
Worcester, Mass. R. S. T.

ANSWER—The number of poles in a stator can be determined by connecting a battery to the terminals and using a compass to determine the number of poles—as a matter of fact, this is a common test which is frequently employed.

If the machine is star-connected, the battery is applied to the start and finish of a phase, but if it is delta-connected the delta is opened and the battery connected to the two ends opened. A piece of chalk is used to mark the compass deflection on the core as the compass is moved over each pole. The number of times the compass reverses per phase indicates the number of poles.

Another method is to determine the number of coils in a group by counting the series connections. If there are no series connections, then there is but one coil per group; but if two series connections are used, then there are three coils to the group, etc. This does not take into consideration odd groupings, in which groups may have different numbers of coils in them, each circuit or the complete circuit being evenly balanced by proper distribution of coils.

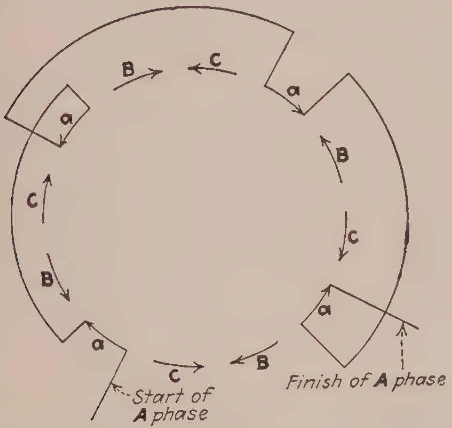
As an example, let us take a machine having 72 slots and, as there are two coil sides to a slot it stands to reason that there are 72 coils. We find two series connections which make three coils per group and since it is a three-phase machine then it follows that (72 coils $\div$ 3 coils per group) $\div$ 3 phases $=$ (72 $\div$ 3) $\div$ 3 $=$ 8, or the machine has eight poles.

In the illustration I have shown a three-phase, four-pole stator with two coils per pole-phase group or a total of 24 coils. The arrow on each pole-phase group indicates the polarity as obtained by a compass. Note that adjacent arrows oppose each other. The number of arrows per phase indicates the number of poles. Only the A phase is shown; B and C are connected likewise and are single-circuit. If this were a two-phase job the arrows would be somewhat different in that they would be in groups of two.

The winding illustrated will have one series connection and is generally referred to as a 1-and-4 connec-

tion, or a top-to-top, referring to the fact that the coil side in the top of the slot is connected to the coil in the top of the slot on the next group.

I would suggest the R. S. T. get in touch with the McGraw-Hill Book Co. for books on armature winding.



Method of finding number of poles in a stator winding.—A compass is used to determine the polarity of each pole-phase group, the reversals of the compass indicating when it passes from one group to the next. The number of pole-phase groups divided by the number of phases equals the number of poles.

He will find it entertaining and of great benefit in understanding what is going on inside his stators.

The corrosion referred to in the second question is caused by the natural sulphation of the positive terminal, caused by discharging too far or allowing the battery to stand for a long period without charging; wrong specific gravity of electrolyte will also tend to cause this corrosion and it can be cured by correcting the above and by the application of vaseline to prevent sulphation. A method of preventing this formation is overcharging at periodic intervals, but this should be done in a careful manner.

E. J. MORRISSEY.
Chief Electrician,
Western United Gas & Electric Co.,
Aurora, Ill.

Misleading Results Sometimes Obtained from Magneto Test

QUESTION.—Sometimes I get rather misleading results through the use of a magneto to determine whether there are defects in some of our electrical apparatus.

Under certain conditions I have found that the magneto will indicate a dead ground, whereas further investigation shows that the equipment is in very good operating condition. Also, I have found that a magneto will sometimes indicate an open in a shunt-field coil, when further investigation shows that the field coil is O.K. I should like to know if any readers have had similar experiences and can explain the reasons for this peculiar action of the magneto. Also, can you suggest other test methods that might be used under the conditions mentioned?

Omaha, Neb. M. P.

ANSWER—Replying to M. P.'s question nearly all magneto tests sets generate alternating current. Since this is the case, the flow of current will not be limited by the ohmic resistance alone, but will be limited by the impedance of the circuit. The impedance of the circuit in ohms is equal to the square root of [the resistance squared plus (the difference of the inductive reactance and the capacitive reactance squared)]. The use of an alternating-current test set on a circuit containing capacitive reactance or inductive reactance would require some information concerning the relative magnitude of the quantities involved. This information is usually not available and for this reason the use of the magneto test set is rather limited in its application.

Practically all electrical machinery has a considerable amount of inductance or inductive reactance. The inductance of a circuit is directly proportional to the magnetic flux, the number of turns, and inversely proportional to the current. From the above it is seen that a large number of turns or an iron core will greatly increase the inductance of the circuit.

A shunt field coil has a very large number of turns and also has an iron core, and consequently has a large amount of inductance. The inductive reactance is directly proportional to the inductance. If the capacitive reactance is zero and the ohmic resistance is small in comparison to the inductive reactance. the impedance will be largely determined by the inductive reactance. All magneto test sets are rated to ring through resistance and not through impedance. In the above case the impedance is very large and the resistance is small; hence the magneto will indicate an open circuit because of its inability to ring through the high impedance of the field coil.

To test shunt field coils, when the magneto indicates an open circuit, direct current must be used. Several dry cells connected in series will in most cases give good results.

When the magneto indicates a ground or a short-circuit when none exists, it is caused by the capacitive reactance of the apparatus. The capacitive reactance is inversely proportional to the frequency and to the capacitance. The capacitance of a condenser is the measure of this condenser to hold a charge. Two conductors separated by a dielectric form a condenser.

From this it is seen that all electrical apparatus must be composed of a large number of condensers.

Alternating current will flow through a condenser and as the magneto generates an alternating current and if the apparatus has sufficient capacitance, the magneto will indicate a ground or a short-circuit where none exists. Therefore, it will be necessary to apply some other test. As a rule electrical machinery does not have sufficient capacitance to cause the magneto to indicate a ground, this being more noticeable on transmission lines.

For insulation testing the Megger manufactured by the James G. Biddle Company, Philadelphia, gives excellent results. For information concerning its operation and construction, refer to literature of that company. It may be of interest to note that the Megger has a direct-current generator and for that reason it may be used where magneto test sets would give misleading results. CHAS. F. CAMERON.

Rock Springs, Wyo.

Cause of Heating of Fuse Studs

QUESTION.—What causes heating of fuses and studs on our switchboard panel, which is built for three-phase, four-wire distribution? The studs and fuses, which are standard make and rated at 600 amp., heat to the danger point and three fuses have been blown at a load of only 400 amp. The panel on which the studs are mounted is of slate and the spacing and carrying capacity of studs and busbars is more than the Code requires. We have aligned the studs and fuses so closely that a piece of flat steel .001 in. in thickness cannot be pushed in at any point between the clips and fuses. Suspecting loose contacts to be causing the heat, we have used wood clamps on the fuses and clips with no result. Reducing the load from 400 amp. to 200 amp. does not lower the temperature to a point premitting the hand to be placed on the fuse clips. There are no iron washers on the studs and renewable fuses of standard and reliable manufacture are in use. The neutral fuse, however, does not heat. Our voltage is 220 volts across the phases and 127 volts from neutral to any phase. Can this heating be caused by mineral veins in the slate panel? It is impossible to feel any current in the slate by wetting the hands and placing them on the slate. The heated area does not extend back more than 10 in. from the fuse studs and does not reach the main bus which is composed of two 3-in. x ½-in. busbars. I shall appreciate your help on the problem.

Elgin, Ill. A. B. A.

ANSWER—Referring to A. B. A.'s trouble with fuse clips, we have had somewhat the same trouble except that we did not have renewable fuses. Our circuits are straight three-phase, with no neutral. The circuits were fused for 400 and 600 amp. The studs and clips would get so hot that they would set fire to the fuse casings before the fuse would blow.

We traced our trouble to poor contact between the

fuse and the clip; so now, by frequent inspections we find the fuses that are heating before any damage is done. Immediately upon the first sign of heating, the fuse is taken out and both clip and fuse block are polished with very fine sandpaper. If this is done before the clip gets so hot that the temper is taken from the copper, no further trouble will result.

But, if you don't get them in time, and the copper gets so hot that it colors up and starts to scale, it is almost impossible to get the clips back to normal.

We had so much trouble with our heavily-loaded circuits, before we found the remedy, and had so many fuse renewals that we have replaced all of our fuse panels with oil circuit breakers, but even these cause some trouble. HAROLD H. STEELE.

Marblehead, Mass.

Connecting Generator to Bus

QUESTION.—In the power house of our lumber mills we are planning on installing a 6,000-kw. three-phase, 480-volt, 9,000-amp. turbo-generator. To the bus there are now connected an 800-kw. and a 2,000-kw., 480-volt generator. I would like to know what readers would recommend for connecting the 6,000-kw. generator to the bus. Should cable be used, and if so, how should it be arranged so as to eliminate the inductive effect and its consequent heating due to the heavy current flowing? Would it be better to use busbars and if so, how should they be supported and arranged so as to reduce the induction? Any recommendation that readers can give for the layout of the connection between the generator and bus will be appreciated.
Bellingham, Wash. E. M. D.

ANSWER—In answer to the above question by E. M. D., my advice would be to approach the problem with caution and get the best advice available. The writer assisted in the solution of this problem on one occasion and has used a different solution on subsequent problems in order to secure a proper layout of the connections.

The installed cost of the electrical equipment for a unit of this current rating is excessive in proportion to the kilowatt capacity, the switching equipment is cumbersome and of special design, deliveries are slow, and some equipment is none too satisfactory in operation. The unexpected difficulties from induction may form a very appreciable addition to the expense and trouble incident to getting the new unit into operation.

In 1916-17 one of the copper mining companies installed a 6,000-kw., 480-volt, three-phase, 60-cycle, turbo-generator as an addition to a plant having one 2,000-kw. turbo-generator and three 1,250-kw., engine-driven units.

Preliminary designs and cost estimates were made for both copper bar and cable connections from the

generator to the switching equipment. The cable arrangement gave the best installation in this case. Eight 2,000,000-circ.mill, v.c., single-conductor cables per phase were used.

This arrangement required 24 runs of 80 ft., totaling 1,920 ft. of cable. To avoid induction drop the cables were made up in sets of three, one set for each phase, and each set was given a complete twist in 9 ft. The result resembled an overgrown telephone cable. Large brass castings placed on 3-ft. centers maintained the cables in position and supported the weight. Micanite bushings protected the insulation where the cables passed through the supporting castings. The inductive drop was negligible and the finished appearance was neat and workmanlike in every particular.

Two, three-pole, 5,000-amp., electrically-operated carbon circuit breakers were connected in parallel for the main switch. These were arranged to be operated either singly or together from the switchboard. In synchronizing one breaker was used, the second breaker being closed after the machine was paralleled.

The bus leaving the switches was divided into six parallel sets of bars. A number of additional feeders were added at this time, and the total new copper to reinforce the existing bus system was approximately 19 tons of ¼-in. by 5-in., hard-rolled copper bar.

A short-circuit, which developed on the bus shortly after the new bus was placed in commission, demonstrated the wisdom of wide spacing of the bus and secure anchorage of the bars. An 8-in. to 10-in. clearance should be maintained between uninsulated conducting parts, or suitable barriers should be installed.

The copper should be figured very conservatively; the current density should not exceed 500 amp. per sq.in. Where more than five ¼-in. by 5-in. bars are required, the bus should be split into two or more parallel runs. Great care should be exercised in the make-up of all joints and taps in the bars to prevent them from becoming overheated and causing trouble.

All iron should be eliminated so far as possible from the bus structure and adjacent parts. Brass or bronze should be used for bolts, washers, bus clamps, but supports and framework. In the above installation, extra-heavy, 1¼-in. brass pipe was used for the supporting frame. Even with this precaution, trouble developed from induced currents circulating in the framework and heating the pipe. Many of the joints had to be insulated before this trouble was remedied. Building steel and reinforcing in the concrete were affected. The expense incident to remedying these unexpected troubles was quite large and became quite serious before the remedy was satisfactorily worked out and applied.

The final effect was an entirely satisfactory solution of the problem in that the engineering difficulties were

overcome. From the economic aspect, however, the cost of wiring, control, and metering equipment formed an undue percentage of the total installation cost.

As the problem is given, there appears to be a very considerable increase in generating equipment which presupposes an increase in motor equipment. Probably the most satisfactory arrangement would be the installation of a higher voltage distribution system with stepdown transformers, and transformer connections to the existing system. T. H. ARNOLD.

Osborn, Ohio.

Overload Protection for Generators

QUESTION.—(1) We have installed in our power plant, two 2,000-kva. generators and two 4,000-kva. generators all of which are rated at 2,300 volts, three phase, 60 cycle, 3,600 r.p.m., and are driven by steam turbines. What protection should we have on these generators? Should reverse power relays, or overload relays, or both be used? Are these relays necessary and also what other protection is required on these machines? The four machines are arranged to be parallel together and quite often all of them are running simultaneously. (2) We have installed one 50-kw., 125-volt, motor-driven generator which operates in parallel with two 100-kw. steam-driven exciters for supplying field excitation for synchronous motors. Should we have circuit-breaker protection on these machines and if so, should a three-pole circuit breaker be used? I shall appreciate any information that readers can give me regarding these questions.

Detroit, Mich. R. J. B.

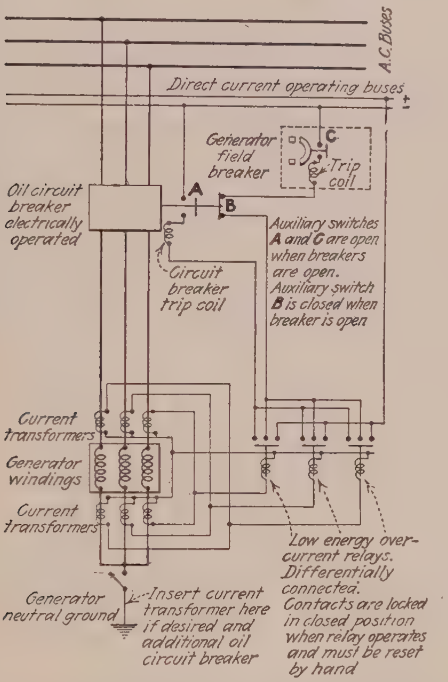
ANSWER—The following are my answers to R. J. B.'s questions regarding the overload protection required for generators.

(1) The accepted practice, when a number of generators are operated in parallel, is not to install any protection against direct overloads on the generating equipment. This practice is due to the possibility of one of the generators being tripped through faulty relay setting or operation, thus throwing more load on the other generators. This condition is particularly liable to occur when the load is variable and the prime movers driving the generators have governing characteristics which are markedly different.

Experience indicates that protection should be installed only for faults in the generators themselves. This protection should operate as quickly as possible and immediately disconnect a generator when the trouble occurs. For this purpose the so-called differential protection is most used. To apply this, it is necessary, however, to have the ends of each phase winding brought out of the generator winding so as to permit the insertion of current transformers. While this is possible in a new generator, those of the older type usually have only three line terminals and the

bringing out of the other three may not be a simple or an easy matter. In these cases a reverse power relay could be installed, but the protection would not be as good as with the differential method.

The accompanying diagram shows the connections for the differential protection of a three-phase generator. The connections are shown for the condition



Connection scheme for protection of generators. —This scheme provides what is known as differential protection and puts the generator out of circuit in case of faults developing in the winding. It is deemed inadvisable to protect the generator against straight overloads due to too much load.

when the main oil circuit breaker is open. This form of protection consists of balancing the current leaving the generator at one end of the winding against the current flowing through the same section but at the other end of the winding. This scheme of protection is usually accomplished by connecting a current transformer at each end of each phase winding, connecting their secondaries in series, and then connecting a current relay across these secondaries, as shown in the diagram. As long as the secondary currents are equal,

no current will flow through the relay windings. Any leakage of current, however, to other phases or to ground will upset this balance, and send current through the relay. The relay in turn operates to trip the circuit breaker and disconnect the faulty equipment.

The scheme as shown has limitations in that it will not always protect against short-circuited turns in the generator winding. Also, it will not always protect against a low-resistance ground on account of the very small unbalance and also because the very low setting of the relay required would be too sensitive for practical operation. A ground relay can be used if the generator is not connected directly to the bus, but with all machines stepping up separately through transformers there is no trouble. In general the scheme shown is fairly satisfactory without special equipment.

It should be understood that where machines have grounded neutrals and all connect directly to the bus, only one neutral can be closed at one time. Should the generators be operated with a grounded neutral, the differential protective scheme will allow the installation of an additional relay to protect a generator from a fault to ground by inserting a current transformer in the ground connection, as shown in the diagram.

The relay used in connection with differential protection is the same as the straight overload type of relay except that it operates at a much lower current. One manufacturer makes a relay for this purpose that operates at a range from 0.5 to 2.5 amp.

(2) For exciters operated in parallel, experience indicates that a reverse-current relay is sufficient protection. Regarding the question of circuit breakers. nothing is said of the type of machine in service, but under any condition for a straight shunt or compound-wound machine a two-pole breaker on a two-wire excitation system is satisfactory.

C. OTTO VON DANNENBERG.

Electrical Division,
General Engineering and Management Corp.,
New York, N. Y.

Voltage Rating of Lamps Used for Synchronizing

QUESTION.—In synchronizing two 440-volt alternators by using lamps in case the synchroscope should fail, what voltage rating of lamps should I use, and how many of them? Should I provide lamps enough for 880 volts or 440 volts?

Indiana Harbor, Ind. A. R. D.

ANSWER — Referring to A. R. D. in the process of synchronizing, the circuit is arranged with the two

alternators and lamps in series, the lamps being across the switch.

As each alternator is delivering 440 volts, it is obvious that there is a possibility of getting a circuit of two electromotive forces opposing each other, like two batteries in parallel, plus connected to plus, and negative connected to negative, the only difference being that with batteries the electromotive force is constant, while with the alternators it is changing at the rate of 120 times per second on a 60-cycle circuit. Considering one instant in one cycle of the alternators for comparison with the batteries, there would be zero voltage on the lamps when the voltages are opposing each other which is, of course, when the plus terminal is connected to plus, speaking of the instantaneous values. This is the time to close the switch—when there will be no current flow from either machine to the other, as in the case of the batteries.

With vectors, it is obvious that a voltage of 440 opposing 440 gives a resultant voltage of zero, because they are equal and opposite and the alternators are in phase, synchronized with each other. When the alternators are out of phase by the maximum amount of 180 deg. the effect is like reversing the plus and minus wires of the batteries and the voltages then add up, because they are in series with the lamps serving as a load in a series circuit. Consequently, as the total voltage would be the sum 440 plus 440, or 880 volts, the lamps must be arranged to stand that much without burning out.

If the lamps were used with the synchroscope, they would be bright when the synchroscope hand is down, and dark when the hand is up on the zero point, each revolution being one cycle difference in the frequency of the alternators to which the synchroscope or lamps are connected.

EDWARD A. GIBBS.

Boston, Mass.

Changing 25-Cycle Brake Coil to 60-Cycle Service

QUESTION.—I am having a little trouble in changing over a brake coil from 25-cycle to 60-cycle service. This coil is used on the brake on the hoist motion of a 10-ton traveling crane. The coil was originally wound with about 1,400 turns of No. 21 magnet wire for 25-cycle service. I have rewound the coil using 800 turns of No. 15 wire, but the coil only lasted a few days before burning out, and it does not seem to have the lifting power of the old coil when used on the 25-cycle service. This coil was formerly connected across a 440-volt, 25-cycle power supply and will be used on the same voltage for the 60-cycle service. The diameter of the smallest turn is about 2 in. and the largest turn about 4 in. The coil is in reality a solenoid with a plunger working through the center of it. Can some reader tell me how many

turns to use on this coil and what size of wire should be used in order that I may use it on the 60-cycle power supply?
Green Bay, Wis. H. B.

ANSWER—In reply to H. B.'s question, the number of turns in the coil is, for practical purposes, inversely proportional to the frequency, thus: $N_1 : N_2 :: F_2 : F_1$, where N_1 and F_1 represent the original number of turns and frequency, respectively, and N_2 and F_2, the new number of turns and frequency. Then $(1{,}400 \times 25) \div 60 = 583$, say 600 turns.

The corresponding larger size of wire to use is No. 17. Since the winding volume is not given, I checked this, based on s.c.c. wire and find that No. 17 wire will not quite fill the winding space. Therefore, each layer of wire should be well insulated from the succeeding layer by dry insulating paper, to make the diameter of the coil as large as conditions will permit to reduce the heating.

The coil apparently is used on a shunt brake, intermittent duty and should be dipped or impregnated in insulating varnish. In many cases it is cheaper to obtain the proper coil from the manufacturer of the apparatus as it is oftentimes difficult to wind and treat coils properly with the equipment at hand.

Bobbin-wound coils are dipped in heated insulating varnish and then baked for several hours. Form-wound coils are impregnated by being placed in vats with the insulating compound and subjected to pressures up to and including 100 lb. per sq.in The coils are then removed and baked for several hours in an 18- to 20-in. vacuum. This treatment removes all of the moisture and keeps the coil from absorbing moisture. Also, the insulation between adjacent turns and layers is very much improved. E. H. LAABS.

Engineering Dept.,
The Cutler-Hammer Mfg. Co.,
Milwaukee, Wis.

Electrical Service

Wires, Insulation, Conduits, Storage Batteries, Demagnetizing

Where Should I Use This Kind of Wire?

QUESTION.—Most manufacturers of wire for use in house wiring and in industrial plants make three kinds of wire; a Code wire, an intermediate grade and a 30 per cent rubber compound grade. I should like to learn from other readers whether they use all three grades around their plants and if so, the basis on which they decide the grade that shall be used for a certain application. Do you find any of these grades unsuited for industrial plant use? I shall appreciate any information that you can give me regarding the proper application of these three grades of wire.
Newark, N. J. B. S.

ANSWER—Code wire is not of the highest quality, but represents wire that will pass the comparatively easy tests required by the Fire Underwriters.

What, in the question is referred to as "30 per cent rubber compound grade" would be better designated as 30 per cent Para or Hevea rubber. The rubber compound containing that proportion of the grade of rubber specified is, when properly made, the highest type of rubber insulation.

The intermediate type generally contains about 25 per cent of Para or Hevea rubber and has insulating qualities lying between the other two types of rubber insulation.

If you leave the wiring of your plant to a contractor and do not specify what kind of rubber insulation he must have on the wire, you will get Code wire for it is the cheapest that will pass the Underwriters' requirements. If you want the best type of insulation, either because you cannot afford to have shutdowns on account of breakdowns of the wire, or if you have unusually difficult conditions to meet, due to dampness or special manufacturing processes, use the 30 per cent Hevea or Para compound. If you want something better than the Code wire, but do not think that you need the very best insulation, or if you cannot afford to pay the price asked for it, use the intermediate grade of insulation.

I do not mean to insinuate that the Code wire is not good. It is good, but the intermediate grade is better, and the 30 per cent Para is best. G. H. McKelway.
Westfield, N. J.

Winding Rectangular Wire on Edge

QUESTION.—I would like some suggestions from readers on how to wind coils, using rectangular wire or ribbon. These coils have to be wound with the copper on edge. My particular problem is the mechanical operation of winding the thin copper strips on edge without using too elaborate a machine. To be specific, I desire to wind both a round and an approximately square coil, using $\frac{1}{16}$-in. by $\frac{3}{4}$-in. copper ribbon. The diameter of the core of this coil should be 1 in. and in the case of the square coil, the side should be 1 in. I also desire to make up a coil around a 1-in. core using strip copper 0.01 in. by 1 in.
Bloomington, Ill. A. S.

ANSWER—In reference to the question of A. S., I have never had any actual experience with wire coils of the size he has in mind, but the following method has been satisfactory for winding large, oblong coils of copper strip $\frac{1}{8}$ in. thick by 1 in. wide.

The copper strip is clamped securely to the faceplate of a lathe and formed about an arbor. A hand tool of convenient size made of cold-rolled steel of suitable thickness and width is used for guiding the turns of copper strip. This guiding tool has a slot of sufficient size to slip over the strip, while the end is made in the shape of a hook to fit tightly against the arbor. When the lathe is started slowly, the tool is held firmly in the hand and the copper is fed through against tension. The thickness of the slot side next to the faceplate may be about $\frac{3}{16}$ in. as the coil can be easily pressed together after finishing.

The above method will, of course, serve only for round coils. However, square coils can be wound by mounting a similar guide in the tool post of the lathe, with provision for allowing the guide to rock up and down slightly and thus follow the slight up and down motion of the copper strip. The coil can be wound without much trouble if the copper is held firmly upright while making the turn. There will be a slight widening of the strip on the inner edge but this will not be enough to be objectionable.

This method of winding round and square coils is very simple and if it works satisfactorily, as it probably will, A. S. will have a means of doing the job without an elaborate machine, and at a very low cost.

J. M. WALSH.

Ass't Chief Engineer,
Gurney Elevator Co.,
New York, N. Y.

What Kind of Wire Should Be Used?

QUESTION.—We are having considerable trouble from grounds and shorts due to the insulation failing on the wires running from our pyrometers to the indicating and recording mechanisms. The pyrometer points are located in the stills and furnaces of a refinery,

and the indicating instruments are 200 to 300 ft. away. Consequently, the wires are subjected to considerable heat at one end of the line while the other end is cool. The wires are carried in conduit and we have trouble with condensation in these pipes. Ordinarily rubber-covered, double-braid wire rots out in less than six months. The so-called "flameproof" wire has not proven satisfactory in this application. Can any reader tell me what I can do to correct this trouble?

Tulsa, Okla. L. A. N.

ANSWER—I would offer the following suggestion to L. A. N. as a remedy for the trouble that he is having. Three years ago we had similar difficulty; our trouble was caused, apparently, from condensation due to warm air entering one end of the conduit and as this warm air strikes the cold section of the pipe, moisture is bound to form on the conductors and on the inside of the conduit, causing the trouble.

To remedy this we plugged both ends of the conduit using plaster of paris. This stopped the passage of air and we had no further trouble. A. C. BARKER.

Chief Electrician,
W. S. Libbey Co.,
Lewiston, Me.

Changing Two-Phase, Four-Wire System to Two-Phase, Three-Wire System

QUESTION.—Our power supply is from a two-phase, four-wire system. For various reasons I wish to change the distribution to a two-phase, three-wire system. Will some reader tell me how to determine which wires of the four-wire system should be connected together to form the common or neutral wire? Is it possible to tie together the wrong pair of wires to form the neutral? How should the four-wire, two-phase motors be connected to the three-wire system? Are there any precautions to take in connecting motors to the three-wire system? Will this change affect anything else in the plant?

New York, N. Y. J. M.

ANSWER—The following is my method of solving the problem given in J. M.'s question in regard to changing a two-phase, four wire system to a two-phase, three-wire system. The most complete method of making this change would take into consideration the relative polarity of the two phases, that is, after the change from four-wire to three-wire had been made, the phase rotation in the three-wire system would be the same as that of the four-wire system. By this method it would be necessary to determine the polarity of each phase in both the four-wire and three-wire systems, so as to make them agree. The method of determining polarity can be ascertained from the very excellent article by L. P. Staubitz in the December, 1924, issue of INDUSTRIAL ENGINEERING. This method outlines the method of determining polarity at the transformer terminals. J. M.

could also determine the polarity at the watt-hour meters located at the source of power supply.

In case neither of these methods could be applied, J. M. should measure the voltage across different pairs of wires until he finds a pair giving zero voltage. This pair should be connected together and the voltage measured between the two remaining wires. The measured voltage should equal 1.4 times the voltage across either phase. Should he connect two wires of opposite polarity together to form the common wire it would not cause any trouble except that it would change the direction of rotation of the rotating field, and a motor connected thereto would revolve in the opposite direction. This could be readily changed, however, by interchanging leads at the motor.

I would suggest that no fuse be placed in the neutral or common wire. The current in the neutral wire is 1.4 times the current in either of the outside wires. If the neutral fuse should blow, the motor will run single phase and since the resulting voltage is 1.4 times the normal voltage between one outside wire and neutral, considerable damage to the motor might result. Moreover, if the three-wire, two-phase system is used for lighting purposes, a blown fuse in the neutral would result in certain lamps being supplied with over-voltage, and others being supplied with under-voltage, in case of load unbalance on the two phases. Assume that one phase is loaded with five 100-watt, 110-volt lamps while the other phase has only one such lamp. Since the single-phase voltage on each phase is 110 volts, the voltage between the two outside wires will be $1.4 \times 110 = 156$ volts. If under these conditions the neutral fuse should blow, each of the five lamps in one phase will receive only 26 volts, while the one lamp in the other phase will have 130 volts applied to it.

The only other change, aside from those that I have mentioned, is to give the neutral wire sufficient capacity. Inasmuch as the current in the neutral wire is 1.4 times the single-phase current, the neutral wire should have a current carrying capacity that is 1.4 times that of either of the outside wires. P. VAN HERK.

Bressoux, Liege, Belgium.

Changing Wire Insulation

QUESTION.—I am planning to rewind the armature of an Autolite generator. This armature was originally wound with No. 18 single-cotton-covered wire. Can some of the readers of this column inform me what results I will get if I rewind this armature with No. 18 enameled wire? I shall be grateful for your help.
Marietta, Ohio. E. L. W.

ANSWER—In answer to E. L. W., you may rewind the armature with No. 18 enameled wire, without in

any way changing the operating characteristics of your machine.

By using enameled wire a better insulated armature will result, and since the outside diameter of the enameled wire is less than that of the s.c.c. wire, no difficulty will be experienced in winding the required number of turns on the armature. C. L. UMBERGER.

Chief Electrician,
Premier Coal Co.,
Middlesboro, Ky.

Grouping of Wires in Conduit for Two-Phase System

QUESTION.—I have installed some 3-in. conduit runs, to be used for two-phase power supply circuits. These conduit runs are about 25 ft. long. In them I wish to place 500,000-circ. mil cables and since it is possible to get only three cables of such size in a 3-in. conduit, it will be necessary to group the cables in two conduits. Will it be satisfactory to place the two A-phase cables in one conduit and the two B-phase cables in the other? In a three-phase system, this should not be done; hence, I am doubtful about doing it with two-phase cables. Would it be preferable to place one A-phase cable and one B-phase cable in each conduit? If so, which of the two B-phase cables should be placed in one conduit with the first A-phase cable? Please give me some information on these points.
St. Lambert, Quebec, Can. J. M.

ANSWER—Referring to the question asked by J. M., if he puts one wire of the A phase and one wire of the B phase in separate conduits, he will have trouble. In addition, the National Electric Code will not permit doing this.

To avoid trouble, place the wires of A and B phases in the same conduit; otherwise there will probably be heating caused by induced currents in the conduits.

H. J. ACHEE.

District Line Supt.
Southwest Light & Power Co.
Elk City, Okla.

Increasing Thickness of Slot Insulation

QUESTION.—I have a 3-hp. Allis-Chalmers induction motor that is connected two-parallel star. The motor has 48 slots and 48 coils consisting of 25 turns of No. 16 double-cotton-covered wire and is rated at 220 volts, 9 amp., 1,200 r.p.m. This motor gets very hard service, although the load is not excessive, and I would like to decrease the size of wire in it. What change would have to be made in the pitch if No. 17 double-cotton-covered wire were used?
San Diego, Calif. E. A. F.

ANSWER—In answer to E. A. F., I would suggest that he use No. 16 B. & S. gage s.c.e. wire, which will reduce the amount of wire insulating material and permit the use of thicker slot cells.

The present winding has 50 No. 16 d.c.c. wires per

slot and the insulated diameter of No. 16 d.c.c. wire is 0.0598 in., while that of No. 16 s.c.e. wire is 0.0573 in. or a difference of 0.5098—0.0573=0.0025 in. per wire. Arranging the 25 wires per coil in a square, five wires wide by five deep the width and depth with No. 16 d.c.c. wire would be 0.299 in. Likewise the insulated width and depth of 25 No. 16 s.c.e. wires would be 0.2865 in. or a saving in slot width of 0.2990—0.2865=0.0125 in. and $2 \times 0.0125 = 0.025$ in. of slot depth using the same size wire with a different covering.

Checking further, the present winding is connected two-parallel-star for 220 volts. Then a series-star connection would change the line voltage to 440 volts with 25 turns per coil. Now, we know that a delta connection requires more turns of a smaller wire than the star connection, and that 25 turns per coil with a series-star connection requires a line voltage of 440, or volts per phase equals $440 \div 1.73 = 254$.

Using 25 turns and a series-delta connection the line voltage would have to be 254 volts, but owing to the fact that this motor is to operate on 220 volts, the turns per coil will have to be decreased as follows: The series-delta turns per coil equal $(220 \times 25) \div 254 = 21.65$ or 22, and the size of wire has to be increased in the same proportion as the turns are decreased. No. 16 d.c.c. wire has an area of 2,600 circ. mils while the area of the new size equals $(25 \times 2{,}600) \div 22 = 2{,}954$ circ. mils. The nearest size is No. 15 with 3,250 circ. mils, which would fill up the slot more than the present winding.

However, the new size, with an area of 2,954 circ. mils is only 2,954—2,600 or 354 circ. mils smaller than the No. 16 d.c.c. wire of the original winding. Accordingly 22 turns of No. 16, d.c.c. wire connected series-delta are better to use than 25 turns of No. 17 d.c.c. wire in series-delta, since the latter has an area of 2,030 circ. mils, or a difference in area between No. 16 and No. 17 of 2,600—2,030=570 circ. mils. Judging from these facts, the best winding for this motor for normal rating would be 22 turns of No. 16 s.c.e. wire with the same coil pitch and connected series-delta for 220 volts.

The use of 22 turns per coil means six less turns per slot which, with the room gained by using single-cotton-covered and enameled wire will allow the use of thicker winding cells. The coil pitch does not affect the size of wire except on very close designs where the chord factor changes the number of effective turns, which varies the torque and the current required to produce it.

The above winding will meet the conditions E. A. F. requires and will be found satisfactory under load.

A. C. Roe.

Wilkinsburg, Pa.

How to Use Megger for Testing Insulation of Motors

QUESTION.—I wish some reader would give me a few suggestions on the proper method of using a megger for testing the insulation resistance of motors. I should also like to know what is considered a satisfactory reading when testing 110/550 volt, a.c. and d.c. motors ranging from 5 hp. to 50 hp.

Latrobe, Pa. J. K. W.

ANSWER—Answering J. K. W., the best instructions for using a specialized instrument such as the megger are those issued by the manufacturer. Assuming that J. K. W. does not have any printed directions on the use of this instrument, the following extracts from James G. Biddle's catalog may be of service to him:

(a) To use the megger testing set, place it on a firm and fairly level base and without connections of any sort to the terminals, turn the crank in a right-hand direction at about 120 r.p.m. The pointer should promptly move up the scale and stand over the infinity mark.

(b) Short-circuit or place a low resistance between the earth and line terminals. When the crank is turned the pointer should promptly move down the scale to zero.

(c) Connect the testing leads to the earth and line terminals. If the leads are held in the hand or touch anything and, while turning the crank the pointer indicates less than infinity, there is a leak somewhere which must be removed, before proceeding with the test. If there is no leak between the leads, you may proceed to test the equipment.

(d) Connect the leads to the apparatus to be tested and turn the handle of the megger at the proper speed. While turning observe the position of the pointer on the scale; the reading indicates the value of the resistance under test.

When testing motors that have just been installed, connect the line terminal of the megger to a lead, the commutator or an exposed conductor of the machine, and the earth terminal to the shaft or some bright part of the frame. Test the insulation resistance. On a cold machine this should be at least 1 to 5 megohms. The lower value applies to large machines. Be sure when making the test that all circuits are properly connected. If all of the circuits are not connected together, as in the case of a separately-excited generator, test each circuit or group of circuits separately.

When testing motors in service, the procedure is the same as for a new installation. When a motor is warmed up the insulation resistance will be lower

than when cold. For testing 110-and 220-volt apparatus, particularly if it is old, it is best not to use a megger generating over 500 volts unless the insulation resistance has been proven to be quite high. It must also be remembered that when making megger tests the equipment under test must not be live.

The standards of the American Institute of Electrical Engineers require that the insulation resistance of a machine at its operating temperature shall not be less than given by the following formula: Insulation resistance in megohms = voltage at terminals ÷ (rating in kva. plus 1,000).

This formula applies only to dry apparatus, not oil-immersed.

In the case of a 50-hp , 550-volt motor, this equation would be written: Insulation resistance in megohms = 550 ÷ 50 + 1,000 = 0.5 megohms, approximately. In this example I used the rating of the motor in horsepower instead of the rating in kva., but the error introduced thereby can be considered negligible for most purposes. E. I. PEASE.

Ford Worden, Wash.

How Much Insulation Should Be Put on Cable Splices?

QUESTION.—Can some reader tell me how many layers of varnished cambric tape should be used for insulating the splices of lead-sheath power cables of the following voltages: 110, 220, 440, 550, 4,000 and 20,000 volts. Do you think some other kind of tape preferable for this work? I shall be grateful for any information that readers can give me regarding the amount of insulation that should be used when splicing cables of the above voltages, and also for any other information or suggestions as to the best method of handling it.

Toledo, Ohio. S. J. M.

ANSWER—In reply to S. J. M.'s question regarding insulation for power cables, I would suggest using one layer of splicing compound (unvulcanized rubber tape) covered with half-lapped friction tape. The rubber tape should be pulled on tightly enough to stretch it to about half its regular width. This insulation is for use on 110-volt cables. One layer of varnished cambric can be substituted for the rubber, if desired. The rubber will stand about 300 volts per mil of thickness. The varnished cambric tape will stand about 1,000 volts per mil of thickness. The tensile strength of either of these tapes is not great and both should be protected by friction tape or some other protective tape. The average roll of varnished cambric tape is from 0.010 to 0.015 in. thick by ¾ in. wide. Other widths and thicknesses can be obtained.

All cables below 600 volts are insulated practically

alike, using two or three layers of varnished cambric tape half-lapped and covered with cotton or friction tape. The cotton should be painted or have hot paraffine poured over it because this tape when untreated has a dielectric strength of only 250 volts per mil, but when treated the breakdown voltage is 1,000 volts per mil. On 4,000-volt cables use from three to five layers of half-lapped varnished cambric tape, covered with one layer of treated cotton tape.

The 20,000-volt cable is in the extra-high potential class and should have about six or eight layers of varnished cambric tape and one or two layers of treated cotton tape. Over all conductors one or two layers should be wrapped before the lead sleeve is slipped in place. If the joints are not wiped, several layers of P. & B. tape should be applied over the whole and each layer heated with a torch before another is applied. This class of joint should be painted with P. & B. water-tight paint also. This makes a water-tight joint and will remain so if painted at intervals.

GRADY H. EMERSON.

Birmingham, Ala.

Use of Armored, Lead-Sheath Conductor Underground

QUESTION.—Will some readers please give me their experience with the use of 2,500-volt, lead-encased, steel-wound wire such as is put out by some of the large manufacturers and intened to be used underground, and not protected by conduit?

San Diego, Calif. W. P. B.

ANSWER—I would like to give W. P. B. an idea of our experiences with armored steel cable, lead-covered and jute-wrapped outside the steel bands. The company with which I am now asosciated uses as much or more steel-armored cable than any other company in the South. We operate about 12 slopes and several drifts. All mines are supplied with alternating current. The tipple equipment fans and pumps are driven by 2,300- or 550-volt a.c. motors. We have installed both armored and weatherproof cable; the latter is used only on the 550-volt circuits.

Potheads are only used on the powerhouse cables and on the 13,000-volt circuit. Most of the cables are just cut the desired length, the armor stripped back, the ground insulation removed and the rope core cut out at the crotch of the three conductors. The lead sheath is rolled back, so as not to chafe conductor insulation. Then several layers of varnished cambric tape are woven in between and around the three conductors to form a sort of insulating cushion, and to keep the wires spread apart. This tape is covered with several layers

of P. & B. waterproof tape, which is warmed with a blow torch when applied, and this is topped with a heavy coat of insulating paint. A cable so treated is waterproof for a reasonable length of time, but as the varnish ages and dries out, the moisture penetrates the cracks and will cause a breakdown to ground. These crotches or splices should be painted with a good insulating varnish ever so often, according to conditions under which they operate.

Another method that I have used for crotching cables is to use linen tape and dip it in boiling or hot paraffin wax, dipping every time a layer of tape is applied, and dipping the finished crotch several times to be sure of a heavy outside coating. The above method is simple and requires no great mechanical skill; almost any mechanic around the mines can make a simple and reliable cable repair with a little practice. But cables so treated must be inspected at regular intervals, or they will be a constant source of trouble; at each inspection we generally paint the joint or crotch.

If cables are put up with potheads and splices are sleeved over with a lead sleeve, they are subject to very little trouble, whether inside or outside the mines, but as cable splicing is, or has become, a trade in itself, there are not so many electricians who are able to do good cable splicing. Although almost any telephone man can give one pointers about cable splicing, and with a little practice and judgment a mechanic ought to be able to make a decent wiped joint.

I know of one large mining company which has several miles of 6,600-volt, three-conductor, steel-armored cable and some without lead or armor, but it is all laid in fiber duct on the trolley wire side of the mine track. They made their joints in junction boxes and the joints were coated with hot paraffin.

In one instance I dipped water off a joint in this cable with an iron bucket; the juice was on and we were afraid the joint might blow if the water were not removed. However, this was not so much of a gamble as one might think, because these joints are waterproof if correctly made and maintained.

Steel-armored cables should not be suspended in bore holes or shafts because their weight soon exceeds their safe strength and as the wires are woven around the core, they tend to flatten out; this crushes the intervening insulation, causing a breakdown. Cables can be supported by suitable clamps, on a messenger; one strand of tiller rope can also be used to tie it to messenger cable.

There is one objection to cables and it is this: when one cable on a system becomes grounded and does not blow a fuse or knock the breaker, all of the other weak cables or joints are subjected to a strain until the defective cable or part is removed. When one cable

breaks down several more are likely to follow suit, if many are in operation. GRADY H. EMERSON.

Birmingham, Ala.

Wiping Lead Joints in Lead-Sheath Cable

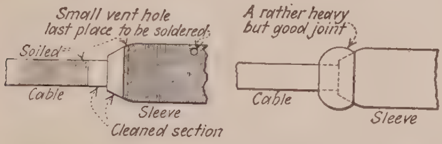
QUESTION.—I should like to have readers give me some information on how to go about wiping joints in lead-covered, three-conductor, 2,300-volt cable. I should like to know how to prepare the joint for wiping what materials should be used, how to wipe the joint, and any precautions that should be observed in wiping the joint.

Benoit, Ala. G. E. W.

ANSWER—In reply to G.E.W.'s question it can be said that wiping joints is an art. It requires months of practice, and results in many burnt fingers and spoiled sections of cable. It is not readily taught by books, but rather by apprenticeship to a skilled worker. After paying close attention to his methods, much patient practice is required on the part of the apprentice.

If it is possible for you to secure a lead worker, a good plumber or a telephone cable splicer, I would recommend such procedure as most advisable.

A plumber, if a good lead worker, will be able to wipe the joints that need attention and at the same



Method of preparing a cable joint for wiping.—At the left the cable and sleeve have been shaved with shave hook and the bright surface covered with tallow to prevent oxidation. The right-hand illustration shows the completed joint.

time can give much valuable instruction. He may, however, spoil the insulation by applying too much heat, for he is accustomed to using half-and-half solder, a mixture of half lead and half tin. Wiping solder for cable splicing should be done at a temperature which is lower than is customary with regulation plumbers' solder. A solder composed of one part tin and two parts lead, that fuses at 440 deg. F., can be used for cable work, although some workers prefer a still lower working temperature. In order to lower the working temperature under 440 deg. F. a quantity of bismuth may be added. Equal parts of tin (pure), lead, and bismuth will lower the working temperature to 250 deg. F. An experienced man, working in a shielded

place which is free from drafts, can produce satisfactory results with a great deal less bismuth than a less skilled workman. With the proportions of the solder in the vicinity of three parts tin, three parts lead, and one part bismuth, the melting point will be 310 deg. F. It is desirable to keep the melting point low so that the joint may be wiped quickly without danger of too much heat running into the cable and weakening the insulation.

The wiping is done with wiping cloths. These can be purchased in various sizes and several will be needed. R. M. Starbuck & Sons, Hartford, Conn., and J. W. Johnson, Wheaton, Ill., sell wiping cloths. Also both firms handle publications on wiping joints and plumbing work.

For each joint, the quantity of solder varies according to the size of cable and the skill of the worker. This quantity generally varies from $\frac{3}{4}$ to 2 lb. of solder per joint. Mutton tallow or tallow candles may be used to prevent the bright lead, that has just been cleaned, from oxidizing. Other materials needed in this work are a good firepot or plumber's furnace, a good-sized cast-iron pot, a double-tipped ladle which is not too large, a blow torch, a soldering iron, a shave hook or lead scraper, a compass, a scratch cloth or steel brush, soil which may be purchased in any plumbers' supply house or may be made from lampblack, glue and water which should be stirred up to a stiff paste, a lead dresser for smoothing and working lead sleeve, a turn pin that is large enough for a sleeve, and a drift plug for swaging through the sleeve to make it smooth inside, when a solid sleeve is used.

Now make up an experimental splice of two cables, insulating the splice well with black varnished cambric, and tape each spliced conductor by using more than enough layers for the voltage to be carried. After cutting back the lead sheath, cord the conductors or tape them together, after which insulate them again to a width of 5 or 6 in. each side of the splice. Apply a couple of layers of white cotton tape or use one layer of asbestos paper and around it wrap one layer of the cotton tape; this latter combination will provide the best heat insulation. You are now able to determine the inside diameter of the lead sleeve. The sheet lead can be $\frac{1}{32}$ in. thick, although a $\frac{1}{16}$ in. thickness is preferable. The over-all length of sleeve can be determined by measuring across the splice from the end of the lead sheath on one cable to the end of the lead sheath on the other. The sleeve should be from 5 to 10 in. longer than the splice depending on how much of a lump has been made at the splice compared to the diameter of the cable insulation. Generally, the inside diameter of the sheath is made only 25 per cent greater than the over-all diameter of the lead cable.

Next, cut the sleeve out of sheet lead, making it about 4 in. longer than the length of the splice, and allow $3\frac{1}{2}$ times the outside cable diameter for the width of the piece being cut. Take the lead-dresser and beat the lead out smooth. Hold the lead sheet on a smooth mandrel, which is of the diameter of the splice, and beat the lead to a tubular shape. This tubular sheathing is now slipped over the splice, spacing it so that the lap at each end will be the same. Scrape the sides that lap for a distance of $\frac{1}{2}$ in. each side of the lap. Scrape and tin this seam with a copper bit, using half-and-half solder. Beat the ends of the sleeve into a cone shape, keeping the surface smooth at each end so that it will join tightly to the lead of the cable. If you have made a bulky splice, it may be necessary to make a larger sleeve, or two small "V" cuts may be made in the ends of the sleeve, although this latter procedure is considered poor practice when a good job is desired.

Scratch the ends of the lead cable with the wire brush for a distance of about 14 in. at each joint. Apply the plumbers' soil and then let it dry well. Then with the compass make a mark around the cable and the sleeve at a distance of 1 in. to $1\frac{1}{4}$ in. from the place where the sleeve joins the cable as shown at the left of the accompanying illustration. Then scratch the cable and sleeve with a shave hook between the compass marks. Cover this cleaned surface quickly with tallow, so as to prevent oxidation.

Secure cable and sheath in a frame or a vise and proceed to wipe the joint. Pour the solder on the soiled sections until the sleeve and cable are heated to the point at which the solder begins to slip off the joint at the bright or tinned parts. Pat solder back to top of joint with the wiping cloth making certain that the bottom and sides are properly tinned and wiped. Finally, before the solder cools and hardens or begins to crumble, wipe or pack the solder into a smooth, even. symmetrical lump over the entire joint as shown at the right of the accompanying diagram, being sure to leave no exposed, unsoldered seams or holes in the sleeve or cable, exception of the vent-hole in the sleeve, which must be soldered up last with a copper bit.

It might be well to grease your fingers and hands with cup grease so as to prevent the stray solder from burning them too severely. Many little tricks and twists must be found out in practice just the same as one does in learning to swim. By pouring solder on slowly and evenly over the entire soiled section, instead of all in one place, much inconvenience will be avoided. My last suggestion to you is: Don't burn the solder.

AL. FIERS.

Tampa, Fla.

Trouble with Storage Battery Charging Generator

QUESTION.—We are having considerable trouble due to the reversal of polarity on a 50-kw., 120-volt, interpole generator which is used to charge storage batteries on vehicles. The machines were tested for grounds by means of a Megger and a heavy leakage to ground through the acid-soaked benches in the battery charging department was discovered. Having remedied this, the generator was started and immediately the voltmeter reads backwards with no load on the machine. We checked the leads from the machine, but they were of such size and so taped together that it would be impossible to reverse them by mistake. We tried to re-excite the field, but could not; so the leads were reconnected so as to reverse them at the generator and not disturb anything at the switchboard. The generator worked satisfactorily for about three days, when the polarity again reversed itself. We reversed the generator leads to their original position and since then the machine has been operating satisfactorily. I do not know what caused this reversal of polarity and should like to have readers give me their suggestions.
Sacramento, Calif. J. T.

ANSWER—It seems likely that the generator which J. T. is puzzled over, has received enough return voltage to change the polarity of the field.

This could also be caused by other apparatus in the line that would discharge through the field in the event that the circuit from the generator was broken.

There is no reason for not being able to re-excite the fields, as only enough voltage is needed to overcome the residual magnetism.

The re-exciting of the fields can be accomplished by applying current from an outside source to the field (shunt) coils, or by insulating the brushes from the commutator and then closing the main switch.

I would advise J. T. to look around for poor connections, or to consider the possibility of the batteries discharging through the generator. E. J. MORRISSEY.

Chief Electrician
Western United Gas & Elec. Co.,
Aurora, Ill.

Charging Storage Batteries

QUESTION.—Will some reader of these columns please inform me how, if possible, I can make up a unit to charge small storage batteries from a 220-volt, direct-current power supply? The storage batteries range from 1 cell (2 volts) to 6 cells (12 volts) in potential and up to 240 amp.-hr. in capacity. Can I charge these batteries from a lamp bank? If so, how many and what size of lamps should I use, and how should they be connected? Any other information that readers can give me along this line will be greatly appreciated.
Chicago, Ill. W. A. B.

ANSWER—W. A. B. can make up a unit for charging storage batteries by using a lamp bank, or the equiva-

lent of a lamp bank with resistance tubes mounted in standard lamp sockets. It would be much better, however, if W. A. B. were to install a motor-generator set for this purpose because it would be much more economical, as the following calculations show:

A 240 amp.-hr. capacity cell has a normal 8-hr. discharge rate of 30 amp., and should be charged at the rate of 30 amp. for about 10 hr. With a lamp-bank charging outfit the current drawn from the 220-volt line would be 30 amp. Therefore, the energy consumed in charging one to six cells would be 220x30x10 = 66,000 watt-hr. or 66 kw.-hr. At an assumed cost of 7 cents per kw.-hr. the cost of the charge would be $4.62.

If a motor-generator set is used, the generator should have a maximum voltage rating of 16 volts; hence at 30 amp. output its capacity would be 16x30 = 480 watts of approximately 0.5 kw. A 1-hp. motor, drawing about 5 amp. at 220 volts, would be large enough to drive the generator. It follows from this that the cost of charging with such a set would be 5x220x10x0.07 = $0.77.

If it is assumed that batteries are to be charged on a commercial basis, 10 hours per day for 300 days per year, and if we set down $10 and $100 per year as representing reasonable values of fixed charges for the lamp bank and motor-generator equipments, respectively, we find that the cost of charging as assumed is as follows:

For the lamp bank equipment:	
Cost of power, 300 × 4.62	= $1,386 per yr.
Fixed charges	= 10 per yr.
Total	= $1,396 per yr.
For the motor generator equipment:	
Cost of power, 300 × 0.77	= $231 per yr.
Fixed charges	= 100 per yr.
Total	= $331 per yr.

Saving in favor of the m.-g. set = $1,065.00 per year.

This result would have to be modified if the assumptions made do not fit the case under consideration. For a lesser amount of charging per year the saving would be less, while for a larger amount the saving would increase. But if the charging is to be done on a commercial scale, it is safe to say that the motor-generator set is more economical.

The lamp bank equipment can be made up of 60 to 70 100-watt, 110-volt lamps, connected in groups of two in series, in series with the battery. Each group of two lamps can be separately connected to the circuit by means of a small, single-pole switch. This would give a current range from about 1 to 35 amp. All the parts

for this equipment can be bought at any electric supply store.

Resistance tubes mounted in standard Edison lamp sockets can be bought through dealers or directly from the Ward Leonard Co. About 30 to 35 tubes rated at 250 ohms, 200 watts, 220 volts, 0.89 amperes each would be suitable for this purpose, and they are cheaper than the lamps mentioned above.

The motor-generator equipment should consist of a 1-hp., 220-volt shunt motor with starter; a 0.5-kw., 16-volt generator which should be arranged for separate excitation from the 220-volt line; a field rheostat; a series rheostat of about ½-ohm total resistance, 30-amp. capacity; a d.c. reverse-current relay; and two fused line switches, one for the 220-volt line and the other for the 16-volt line.

The series rheostat is to go between the generator and the battery and should have at least six steps for adjusting the voltage of the charging circuit. The reverse current relay protects the battery and the generator in case the 220-volt power fails. The motor-generator equipment can be bought from manufacturers agents in Chicago. For addresses see the E. M. F. Year Book, or consult your electrical dealer.

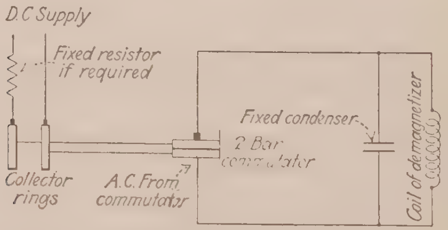
H. H. METZENHEIM.

Newark, N. J.

Operating A.C. Demagnetizer on Direct Current

QUESTION.—Will some reader please tell me of a cheap and simple way of changing a 110-volt a.c. demagnetizer so that it can be operated by direct current at the same voltage.
Norristown, Pa. C. D. H.

ANSWER—It will be necessary for C. D. H. to provide means for reversing the direct-current supply. This



Method of exciting a demagnetizer from a d.c. power supply.—A two-bar commutator is connected through slip rings to the d.c. power supply. By revolving the commutator at a good rate of speed a supply of alternating-current is obtained for the demagnetizer. Resistors and condensers are used as shown to reduce sparking at the commutator.

may be done by mounting two collector rings and a commutator on a shaft, either at the end of the shaft of a small motor or on a shaft mounted in two bearings, which may be belted or coupled directly to a driving motor. The commutator can be made of two parts separated by an insulated break wide enough so that the brushes will not overlap and cause a short-circuit between the parts. If the direct-current supply is fed to the collector rings, an alternating current will be obtained from the commutator.

It may be necessary to insert a resistor, made up of one or more lamps, or a fixed resistance, in the collector ring to limit the current. A small condenser should also be connected across the demagnetizing coil to cut down and reduce the sparking at the commutator. A telephone condenser will usually be sufficient for the average coil.

It is possible to use an electrolytic interrupter of the Wehnet type, but the writer has not found one of these to be satisfactory if very much current is to be handled. C. Otto Von Dannenberg.

Electrical Division,
General Engineer and Management Corp.,
New York, N. Y.

Demagnetizing a Lathe

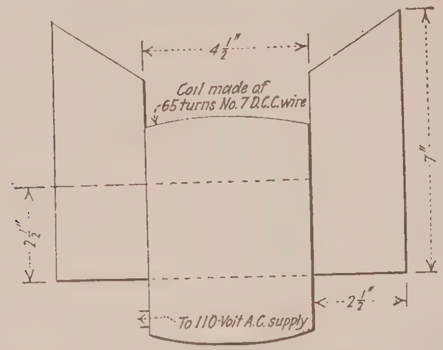
QUESTION.—I have a 24-in. by 10-in. selective head lathe, which is magnetized; at least, when any work is done on the lathe, the chips cause us trouble by sticking to the lathe tool and surrounding lathe parts. It is my opinion that the spindle of the lathe is magnetized. I shall greatly appreciate it if readers will tell me how to demagnetize this lathe. If it is necessary to use a demagnetizing coil, how big should the coil be, how many turns and what size of wire should be used? Also, how many amperes should flow through the coil? Is there any way that I can demagnetize this lathe without using a demagnetizing coil?

Beaumont, Tex. O. C. B.

ANSWER—In answer to O. C. B.'s question, I would say that this trouble may be easily overcome by placing the magnetized parts in a magnetic field that is subjected to frequent reversals. This can be obtained by placing the parts on a growler and then slowly moving the parts away from the growler while the current is on.

The accompanying sketch shows how I made a growler which may be used to demagnetize small machine parts. The core is made up from laminations of sheet iron of the shape shown in the sketch. Enough laminations are used so as to make a thickness of 2½ in. Sixty-five turns of No. 7 d.c.c. wire are wound on the center of the core. This is sufficient for operation from a 110-volt, alternating-current, power supply. For operation on 220 volts, use double the number of turns in winding the coil of the growler.

When demagnetizing parts, be sure to pull the parts away from the growler while the alternating current



Data for making growler that may be used to demagnetize metallic parts of machines.

is still on. Turning the current off before the parts are pulled away has a tendency to magnetize them.

O. C. UMBERGER

Chief Electrician,
Premier Coal Co.,
Middleboro, Ky.

Lamp Consumption Here Too High?

QUESTION.—Our plant is a malleable iron foundry and our lights are operated from 230-volt direct-current power supply. During the first 314 days of this year, we used a total of 972 lamps in 847 outlets, making an average consumption of 1.33 lamps per outlet per year. To be specific, we used 230, 100-watt type C lamps in 275 outlets, or 0.97 lamps per outlet per year. We used 162, 200-watt type C lamps in 160 outlets, or 1.18 lamps per outlet per year. For portables and extensions at molders' benches we used 600, 50-watt, mill-type lamps in 412 outlets, or 1.7 lamps per outlet per year. The large lamps are subjected to slight vibration due to machinery and lineshafting. The lamps burn 9½ to 10 hr. per day. I should like to know whether other readers think that our average lamp consumption is too high. Also I shall appreciate any information regarding lamp consumption in plants having conditions similar to a foundry, as well as in other types of manufacturing plants.

Chicago, Ill. W. A. B.

ANSWER—In answer to W. A. B., I would say that he is to be congratulated, because foundry service is very hard on electric lamps. Owing to the accumulation of dirt, lamps have to be cleaned frequently, which increases the liability of breakage. Also, the use of portable lamps and extension cords tends to shorten the life of the lamps, which is likewise true to a less extent for fixtures subjected to vibration. Based on

an average of 9.75 hr. per day for 314 days the lamps were burned 3,061 hr., which is a trifle over three times the rated life of the lamps.

According to the actual rated life of these lamps, the total consumption would have been 2,970 lamps in comparison to the 972 that were used. However, this comparison is too good to be true for the modern lamp, which is rated for 1,000 hr., but is considered all right to use until broken. After 1,500 hr. the output decreases to such an extent that it produces only about 90 per cent of its rated lumens. Iron and steel plant applications are comparable to foundry lighting and in fact include it. In such a plant having 3,865 outlets, there have been as many as 12,300 lamps charged out in one year. This large consumption of lamps has been reduced recently by good management and improved lamp design.

If it were possible, it might be said that W. A. B. was not using enough lamps per year. Money invested in illumination produces a greater return than any other similar sum spent on plant equipment. A dollar now buys 16 times the illumination that it did 35 years ago. During the past decade the increased return on the investment has been about 62 per cent.

D. W. Blakeslee.

Electrical Engineer,
Jones & Laughlin Steel Corp.,
Pittsburgh, Pa.

What Causes Heating of This Cable Box?

QUESTION.—There are six 1,000,000-circ. mil cables connected in parallel per phase on the cable run between our 2,000-kw. 3,000-amp., 480-volt turbo-generator and the oil switch. These cables are grouped in six conduits, each of which holds one cable from each phase, or a total of three cables. The conduits terminate in the bottom of a sheet-iron distribution box. In this box the cables are regrouped so that all of the cables from one phase go out of the left-hand side of the top of the box; all the cables for another phase go out through the center of the top of the box; and the six cables for the remaining phase go out through the right-hand side of the top of the box. With this arrangement the entire top half of the sheet-iron distribution box heats up. What causes this heating and how may it be overcome? Should I make the box of fiber instead of sheet iron.

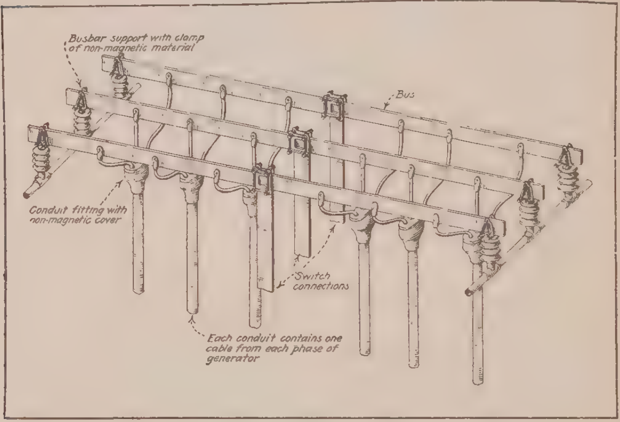
Bellingham, Wash. E. M. D.

ANSWER—In answer to E. M. D., a conductor carrying current is encircled by magnetic lines of force. If the current is alternating, the magnetism varies in intensity and reverses with the current. When a conductor is surrounded by magnetic material this material is magnetized. Alternating current causes magnetic losses due to the changing flux and produces heat in proportion to the strength of the current in the conductors. E. M. D. states that he has carefully grouped the three-phase conductors in steel conduit,

so that each conduit, on entering the bottom of the distribution box, contains one cable from each phase. By this method the magnetic field around the three-phase circuit has been balanced, which is the recognized way of overcoming this effect.

However, in taking the cables for each phase out separately through the top of the distribution box, an unbalanced condition is produced and heating of the upper portion of the box results. This can be prevented by making the distribution box of fiber, instead of sheet iron, as E. M. D. suggests.

I would recommend in most instances eliminating the box entirely and connecting the cables to a bus, as shown in the accompanying sketch. It is generally



The use of distribution boxes for heavy feeder cables may be avoided by employing buses arranged as shown here.

more satisfactory to use copper busbars on insulators, or racked cables in concrete tunnels, as feeders, when heavy currents are to be carried. R. N. VINING.

Electrical Engineer,
Detroit Seamless Steel Tube Co.,
Detroit, Mich.

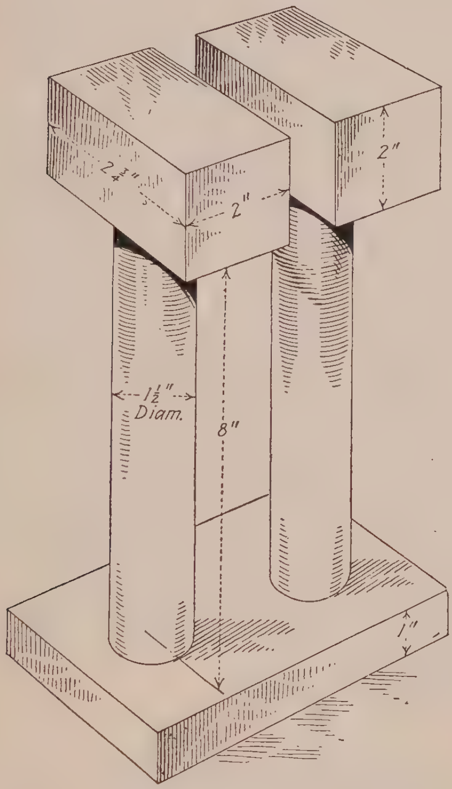
Making a Magnet Recharger

QUESTION.—I wish to build a coil for recharging or remagnetizing magneto magnets. This coil is to operate on 220 volts direct-current. I shall be glad to get any information regarding dimensions of core, turns and size of wire, and so on, that other readers can give me.

Somerset, Pa. G. G. F.

ANSWER—In answer to G. G. F., the accompanying

sketch shows an electromagnet for recharging magneto magnets, which has been found very satisfactory and easy to construct. The base is of cast iron 1 in. thick, with two wrought-iron cores 8 in. long and 1½ in. in diameter mounted on it. Each of these cores is wound with 14,000 turns of No. 27 B. & S. gage d.c.c. magnet wire and both coils are connected in series for use on



Details of electromagnet for recharging magnets.

220-volt d.c. circuits, or in parallel for 110-volt circuits. Where this arrangement is not required, or to make the magnet somewhat cheaper to build, half the number of turns given above and wire of twice the cross-section will make it suitable for service on 110-volt d.c. circuits only.

The two cores are surmounted by wrought-iron blocks, 2 in. high, 2 in. wide, and 2¾ in. long. The com-

plete electromagnet is usually mounted at some convenient point on the work bench so that just the two iron blocks project above the bench. The magneto magnets are recharged by moving them back and forth a few times across the face of these blocks.

P. JUSTUS.

Chief Electrician,
Chandler Motor Car Co.,
Cleveland, Ohio.

Contactors Will Not Close on Low Voltage

QUESTION.—We are having trouble with the contactors failing to close due to low voltage on one of our automatic control panels. The panel is fed from a 220-volt supply, but when the voltage drops considerably the operating coils of the contactors are not strong enough to close them, thereby leaving an open magnetic circuit which causes the coil to roast out. It is rather difficult to provide the correct voltage at this panel all of the time. Can any reader suggest something that I might do to the contactor coil that would enable it to take care of the low voltage condition?

Omaha, Neb. M. P.

ANSWER—In answer to M. P., I would suggest that he try shortening the air gap of the contactors that will not close on low voltage. Quite often there is some means provided by the manufacturer for the adjustment of this gap between the armature and the magnet core of the contactor. If there is, M. P. should find it and use it.

In case no such provision has been made, a little ingenuity on his part should enable him to effect a reduction in this air gap so that the contactor will surely close on low voltage. This adjustment will, of course, make the contactor go in with quite a bit of force when the voltage is up to its full value. If this is objectionable it will be necessary to rewind the contactor coil, which is a job to be referred to the manufacturer.

J. M. WALSH.

Ass't Chief Engineer,
Gurney Elevator Co.,
New York City.

Lightning Protection for Short Overhead Power Line

QUESTION.—We have a 3,300-volt two-phase, 25-cycle, 80-amp. transmission line running a distance of 1,080 meters from our substation to the mouth of our copper mine. At the shaft, this line is spliced to a lead-sheath cable which goes down the shaft a distance of 200 meters where it is connected to a switchboard that supplies other feeders radiating through the mine. The wire and cable used for this transmission line are No. 00 B. & S. gage. The elevation of the country through which the line runs is approximately 4,100 meters above sea level. As the overhead line must have good lightning protection, I wish to install choke

coils and lightning arresters at both ends of the line, but I have heard that choke coils should not be installed in connection with lead-sheath cables. Why is this? Won't some reader tell me how to protect this overhead line against lightning? We now have an oxide film arrester at the substation and a compression chamber multi-gap arrester at the shaft mouth, where the overhead line is connected to the lead-sheath cable. Is this sufficient protection? Should I not use choke coils both at the mine mouth and at the substation? What lightning protection would readers recommend for this transmission line?

Pulacayo, Bolivia. C. L. C.

ANSWER—In answer to C. L. C., it would seem that the best protection could be obtained by running a ¼-in. stranded guy wire over the phase wires on the transmission line poles, grounding this static wire at both ends and at its center. This static wire should take care of most of the lightning.

Very strong choke coils should be used at each end of the transmission line, and C. L. C. should be sure to connect the lightning arresters ahead of the choke coils, but no coils should be connected to the static wire.

I would recommend the types of arresters mentioned by C. L. C. always using a choke coil where an arrester is used. Arresters might be also installed on both primary and secondary sides of the substation, care being taken to see that the ground wire is not smaller than No. 4 B. & S. gage copper wire, is well grounded and that all joints are soldered.

If C. L. C. does not care to go to the expense of installing the static wire he will increase the protection of his transmission line by installing choke coils as previously explained. H. J. ACHEE.

District Line Supt.
Southwest Light & Power Co.
Elk City, Okla.

Plant Maintenance

Installing and aligning bearings, Mounting, Supporting, Shop equipment, Determining shaft horsepower; Gears, Drives, Belts, Clutches, Hangers, Lineshafts; Miscellaneous

Selecting High-Pressure Bearings

QUESTION.—In one of our manufacturing processes the product is rolled under high pressure. We have always had considerable difficulty with the bearings and as we are going to rebuild the machines are considering installing other types of bearings. I would like to know what types of bearings other operating men favor for paper calendars, rubber mills, and cereal rolls, as I believe our problem is similar. Will some readers from these industries please give me their experience with babbitt (including the type), bronze bushings, ball or roller bearings and the method of lubrication which they have found most satisfactory?

Brooklyn, N. Y. J. A. A.

ANSWER—A high-pressure bearing of the type J. A. A. is considering should be of a design to provide automatic lubrication, and of such proportions that the pressure per square inch of projected area is within the limit of the load-carrying capacity of the bearing metal.

The bearing metal should be softer than the metal of the journal so that a minimum of injury would result from seizing. Other desirable properties are: a low co-efficient of friction, a low co-efficient of expansion, high heat conductivity, the property of adhesion, to hold the oil film, the ability to carry intermittent overloads, and the ability to withstand abnormal bearing temperatures. The soft alloy bearing metals yield to the contour of the journal under heavy loads and increased temperatures, which decreases the pressure on the high spots, re-establishes the oil films and so prevents the seizing of the journal. The harder metals, such as bronze and brass, according to my experience, do not have these advantages or possess the most desirable characteristics mentioned.

Genuine babbitt has been used successfully for heavy duty in properly-designed bearings, but I have found under test and actual working conditions in the field that a similar white metal known as Bearite, which is manufactured by the A. W. Cadman Co., is an exceptional bearing metal. This metal can be used in bearings with pressures from 150 lb. to 300 lb. per inch of projected area, with corresponding temperature rises of 70 and 130 deg. F. respectively in the bearing, with peripheral journal speeds of 300 to 1,100 f.p.m.

In the absence of definite data as to speed, load, physical limtations, and the nature of service, no definite proportions or design can be given to J. A. A. The length of the bearing in terms of the diameter, varies according to the nature of the load, and the type of bearing. For heavy journals with fixed bearings, the length is from two to three times the diameter of the journal.

E. H. LAABS.

Engineer,
The Cutler-Hammer Mfg. Co.,
Milwaukee, Wis.

Installing Ball Bearings in Lineshaft Hangers

QUESTION.—We are going to replace the split, babbitted. shaft-hanger bearings on a $2\frac{7}{16}$-in., 72-ft. shaft with new ball bearings. The same drop hangers are to be used. Two solid pulleys are used; the remainder are split, either wood or steel. The shafts are connected with keyed flange couplings. What is the best way to go about making the change? Would it be best to let the shaft down to the floor, or work overhead? What is the easiest way of getting the flanges off and on again? Would it be better to replace them with compression couplings?

Syracuse, N. Y. H. L. G.

ANSWER—The question asked by H.L.G. on whether or not to lower the shaft to the floor when installing ball-bearing hanger boxes depends upon whether the couplings can be removed without undue trouble and what machinery or other equipment is in the way below.

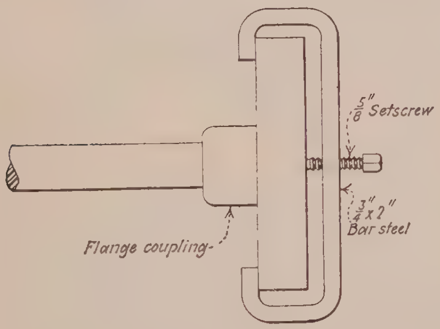
Keyed flange couplings are often put on in such a manner that the man who does the work says, "Well, I hope I don't have to take them off." With the shaft badly battered up and the key sledged in an inch after it should have been left alone, it is a heartbreaking job to remove the couplings. In such a case, drilling out the key or taking the assembled length to a neighboring shop, when the plant does not have such equipment, to have the couplings removed in a hydraulic press, is about the only way to strip the line.

On the other hand, couplings put on intelligently present no great difficulty in their removal. With such couplings more trouble is caused by rust than any other gripping factor. It is suggested that the joints be liberally supplied with one of the "penetrating oils"

that are such good looseners of rusty parts; this should be done nightly for several days before the job is attempted. The couplings should then be easily removed.

All couplings should be provided with two tapped holes for removing, but if there are none, a puller can be used instead. A simple puller which is light enough to be handled easily may be made for the job, if no other is available, from a piece of $\frac{3}{4}$x2-in., or heavier, steel of the form shown in one of the accompanying illustrations and to fit the style of coupling used. In using a puller, if the coupling does not move with moderate screw pressure, it can be started by driving on the hub at the back with a bar between the hammer and the hub to prevent bruising the coupling. Usually, only one blow is required to break the grip and then the piece comes off readily enough.

Changing couplings and bearings is something like painting, in that it is easy to do in an empty building that has machinery or other equipment and stock underneath, it is attended with considerable difficulty. When such is the case the writer prefers to make the bear-



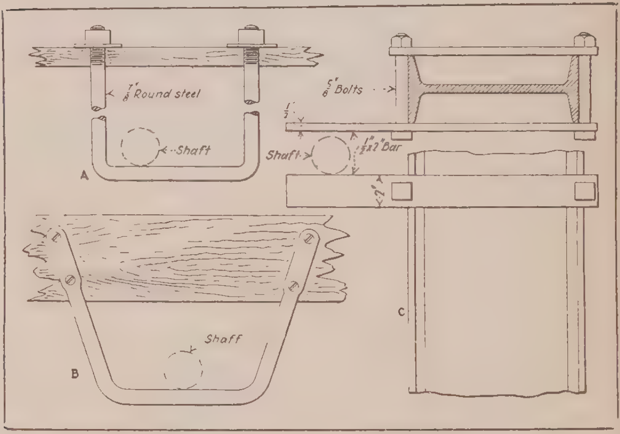
A simple and easily constructed coupling puller which is light enough for use on overhead work.

ing change in the air. Also, if the shaft is kept overhead by the proper type of retainers there is not the risk of a length of shaft getting away and plunging into a machine or valuable stock, as is the case when the shaft is taken down. Likewise, the job of lowering and raising again lengths of shaft, often weighing 600 lb., besides pulleys, is avoided. Ordinarily few belts have to be taken off. Some pulleys must be removed, of course, but by working from both ends of the shaft it is seldom necessary to take off all of them.

To do the work in the air, two or more slings are required. These, and the puller mentioned before, are

simple pieces for a blacksmith to make. Their cost is trifling, as compared with the saving effected, and they can be turned to other uses when the job is done. They have to be prepared in advance; the location must be measured up and the slings made to suit.

Three types of slings are shown in the accompanying group illustration. Slings of the type designated as *A* are used where holes can be bored through the floor above. When this loop-shaped sling is thrust up through the floor, a steel plate is slipped over each end before the nut is put on. At *B* is shown a sling that is meant to be lagscrewed to the side of overhead beams.



Three types of slings for supporting shafting while changing to ball-bearing hanger boxes.—The type of sling shown at *A* is used where it is possible to bore holes through the floor above. Sling *B* is lagscrewed to the ceiling beams. Sling *C* is clamped to steel columns or wood posts. These slings are made to measure and erected before the shaft is loosened. Frequently the construction of the building requires some modification of these slings.

Where columns of structural steel or wood are close to the line of shafting, the type of clamp shown at *C* supplies an easy method of supporting a shaft. The type of sling required depends upon the construction of the building. If the building is of steel and concrete construction, it will be necessary to provide means for attaching the slings.

With drop-bottom hangers, the slings must be erected so that their horizontal run is about 6 in. below the end of the hanger after the cap is taken off. Some designs of ball bearings will require more drop, and others, less. The simplest method of holding up the weight of the shaft while the bottom of the hanger is

being taken off is to have a man below holding it up with a rope passed over some member above the shaft level. Sometimes it is necessary to erect a sheave wheel or screw a hook into a beam or some other part of the structure for the rope to pass over. Often the design of the hanger is such that a rope can be passed over it.

Horses or ladders have to be used and with them it is often possible for helpers to take the weight of the shaft while the mechanic removes the hanger cap. The slings have been put up before the caps are taken off, of course.

For heavier shafts, the writer has found that the portable floor crane enables only two men to proceed very fast with a shaft job. If the crane is not heavy enough of itself, weights are added so that its chain (or cable) can be carried upward and over a sheave erected above the shaft; the winch on the crane is then used for lowering and raising the shaft. For work in rooms with high ceilings the length of the chain is increased by tying a rope on the end of it. Some buildings will permit the use of chain hoists, although they are usually useless because of low headroom.

The writer prefers the compression coupling to the usual keyed flange couplings, provided they are watched for the first few months and taken up, as they should be, after settling to the work. DONALD A. HAMPSON.

Plant Superintendent,
Morgans & Wilcox Mfg. Co.,
Middletown, N. Y.

Bearings in Wet Locations

QUESTION.—It is necessary to operate one of the bearings of a washing device under water. We have not been able to lubricate this bearing and have had considerable trouble due to extensive wear from lack of lubrication and dirt in the water. Babbitted bearings have always been used but I should like to learn the experience of readers with other types of bearings operating under conditions somewhat similar to this. Perhaps someone can suggest a lubricant or method of application which will work. I shall greatly appreciate any information that readers may give.
Des Moines, Iowa. L. D.

ANSWER—Water has no lubricating qualities and, therefore, bearings which are immersed in it for all or part of the time are likely to suffer. Bearings such as described by L. D. offer a problem that has not been solved satisfactorily for several reasons.

No engineer will deny that it would be possible to keep water out of a bearing, any more so than it is possible to keep oil in them and away from adjacent parts, such as the windings of the motor, but the cost of the elaborate construction required would seldom be justified. The second factor in importance is that

of care: although satisfactory means of lubrication may be provided, neglect of this for a single period of operation may start cutting or wear which will continue to grow worse.

When a shaft or shaft bearing becomes scored, the oil passages invariably become clogged, which prevents the entrance of any more lubricant, that otherwise might keep the surfaces in shape. Often, a scored shaft or bearing provides an opening through which water can enter and dilute or displace the lubricant, which action will quickly result in excessive wear.

The writer has had over 15 years' experience with shafts that were running in water and water solutions. The longest period of immersion noted was 11 years for a 3-in. shaft carrying heavy loads and running at 120 r.p.m. in babbitt bearings. We found that better operation was secured by using cast-iron journals in the babbitt, rather than steel shafting. To permit this, the fixtures were cast with extended hubs about 4½ in. in diameter by 8 in. long which were turned to form a shaft and ran in the babbitt. This gave better and smoother running than on the shafts direct, because steel pitted badly in the liquid, which contained a good deal of vegetable matter. The parts would run for years, but when the bearing wore the pitted journals scored more rapidly and the babbitt had to be renewed. This finally raised the maintenance cost to a point where the renewal of all the worn parts was necessary.

The question asked by L. D. does not state whether it is a plain or packed bearing which gives trouble. If it is a packed bearing, outside packing will be used, of course, and of a stuffing box construction best suited for the purpose. The simplest type of construction for the bearing section of a plain bearing (not a packed bearing) is the best.

Where it is improbable that gravity or pressure lubrication will receive much attention, it is better to make no provision for lubrication and to spend in many other ways the amount it would cost.

Stainless steel shafting is now made by at least one mill and a number of concerns produce bearing bronzes that are impregnated with a lubricant or have a base composed of one of the white metals.

The writer would use a combination of stainless steel and this bronze bearing, thus obtaining a longer shaft life before corrosion begins, and a bearing material that would not need lubrication.

These bearings should be given a greater area than for similar bearings not operating under water, but they should be so installed that even an unskilled mechanic could make any replacements when necessary. Without knowing further details, I believe that

this construction would be superior to one more complicated and, also, it would save money.

Anti-friction bearings can be employed satisfactorily if the machine will stand the expense of mounting and protecting. That it is possible to do this is proven by the widespread use of ball bearings in centrifugal pumps. A study of these might reveal a plan that could be simplified and used to advantage.

A bearing that has stood the test of years in pump work is one in which the shaft is completely encased in a non-ferrous sleeve until it is entirely outside the water zone. That this is imperative for all ordinary steels is well illustrated on automobiles. No matter what price car, the water pump leaks after a time. Tightening up the gland will help for a short time only, because the bare steel shaft corrodes and, as this progresses, the water enters the stuffing box and the packing cannot be kept tight on the rough or eccentric shaft.

The sloppiest job the writer ever worked on was in maintenance work in a paper mill, where practically all shafting and machine parts were in water or subject to drip. The Master Mechanic simplified the maintenance because he insisted that all work be put in so that it could be taken out easily after parts had rusted together or corroded loose. The results showed this to be a good plan. DONALD A. HAMPSON.

Plant Superintendent,
Morgans & Wilcox Mfg. Co.,
Middletown, N. Y.

Jackshaft Bearing of Mill-Type Motor Leaks Oil

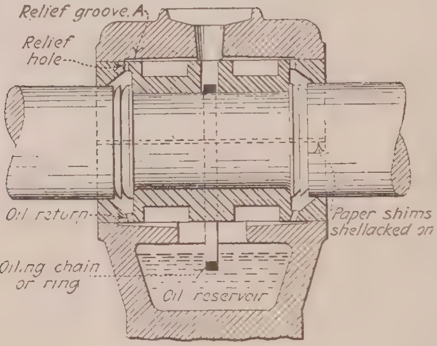
QUESTION.—I am having trouble with oil leakage from the jackshaft bearings of mill-type motors. These bearings are large, running from 3½ to 7½ in. in diameter. They are split and held in brackets which are integral with the motor frame. Both ends of the babbitt bearing extend beyond the bearing housing. There is one oil ring in each bearing. The oil leaks out around the shaft at the ends of the bearings and then drips on the surrounding apparatus. At times the oil will be drawn out of the bearing to such an extent that the oil level will fall too low for the ring to dip in the oil. I shall appreciate it if some of the readers will give me the remedies they have used to overcome this trouble.

South Chicago, Ill. O. C.

ANSWER—Referring to O. C.'s question, it is somewhat difficult to accurately analyze the cause of the trouble in a leaking bearing without knowing whether the bearing is ring oiled, chain oiled or wick oiled. We will consider that the bearings in question are ring oiled.

The illustration shows a cross-section of a typical bearing arrangement. The oil circulated by the ring

creates a pressure which forces it to follow the parting line of the two halves of the bearing toward the outer ends where it clings to the shaft and leaks out. If collars, pulleys, gears, etc., are mounted on the shaft near the bearing, there is a tendency to create a slight vacuum at the ends of the bearing and by reason of the difference in pressure inside the bearing and at its end, the oil is drawn out, leaking down the end of the bearing. Using a heavy oil will not remedy the situation, and will be found to aggravate conditions. Likewise, oil that is thin will flow too freely and leave the bearing in a fine spray.



Shellaced paper shims placed between the bearings halves and a relief groove shown at (A) will prevent oil leakage.

To remedy such leaky bearings a well-shellacked paper shim should be placed at each side between the two halves, so as to close the opening at the dividing line of the bearing halves. Also, if there are no relief grooves in the upper part of the bearing, a groove should be chipped in, extending from the oil-ring chamber to the oil-collecting groove at each end of the bearing, as shown at (A) in the diagram. For general service, a medium oil with a viscosity of 275-310, Saybolt, is recommended.

E. H. Laabs.

Engineer, Printing Equipment Dept.,
The Cutler-Hammer Mfg. Co.,
Milwaukee, Wis.

Checking Bearing Alignment

QUESTION.—I should like to know how to check the alignment of bearings on machines having three or more bearings supporting the same shaft, or where two shafts are coupled together by means of rigid couplings. An example of this is a three-bearing, motor-generator set or a large, heavy-duty motor or pump having a pedestal bearing in addition to two regular bearings. I shall appreciate any suggestions that readers can give me for doing this work.
Chicago, Ill. F. B.

ANSWER—The problem of F. B. in the alignment of relatively short shafts is considerably different from the alignment of long coupled shafts, such as line-shafts. Usually, the parts of such machines as F. B. has in mind which are available for lining up are very short, and often the shafts are completely hidden beneath couplings.

In the case of a motor-generator set, about the only place to do the aligning is on the couplings. If these cannot be removed except at great expense, the tests must be made on the peripheries and between thir opposing faces. Such tests presuppose that the faces and rims of the couplings are true with the axes of their respective shafts; if they are not, they must be turned or ground true before the tests are of any value. Couplings may have been machined concentric with their bores but the commercial allowance on bores and on shaft sizes may be such that the insertion of the driving key will pull them considerably off-center by the time a check is made at the outer surface.

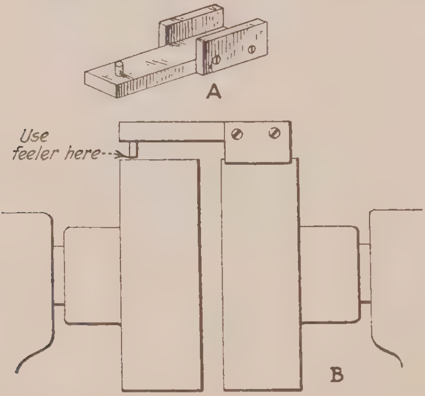
Alignment of shafts can be checked on flange couplings that are true and of the same diameter by the use of a steel rule and paper feeler or thickness gage. It is first necessary, however, to remove the bolts which fasten the flanges together. The rule is placed successively at the top and bottom and at the two sides of the couplings. While resting the edge of the rule on one-half of the coupling, a paper feeler is used between the far edge of the rule and the other half of the coupling. If the paper is tight at all four points it is safe to assume that the shafts are in line, after having made a check test by turning the machines over one-half revolution. A further check is made by applying the feeler between the flat faces of the couplings at the same four points.

With flexible couplings, the space between the two halves may be more than the range of the common mechanic's thickness gage and it must be supplemented by a block that nearly fills the space, or such a block may be filed to an approximate fit and used with a piece of paper as a feeler.

Such a test as described does not level up the machines and this point must be taken up separately. When a set is factory-built and the two units are mounted on a common base, the latter can be leveled up and there is every assurance that the machine is practically level. On small machines of this type, it is sometimes possible to drop a line from the outer shaft ends to the base and to do the same thing on the stub shafts in the center, just back of the couplings, and then to compare these with a line scribed on the base (or a straight-edge) which is used as a datum line.

Couplings are seldom perfectly true and of the same diameter. In that case a simple tool for lining may

be constructed, as shown in illustration *A*, by attaching two pieces of flat iron to a piece of cold-drawn steel and putting a short pin in the outer end. A similar tool may be machined out of a solid block of steel, iron, or brass. The reason for making the tool of this general shape is to form a V-block which will keep itself parallel to the axis when placed on a shaft or other round part. The difficulty of doing this with a piece having a single bearing line, such as a rule, is the chief objection to the first test, as described above. With the concave or V-block, this difficulty is overcome. The method of using this block is shown at *B*. Such a tool is cheap to make and very useful on jobs of this kind;



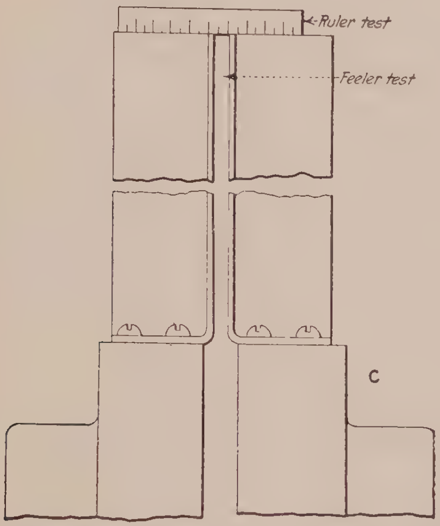
This simple gage, A, is used with a feeler as at B for checking alignment of short shafts at the rim of couplings.

it is equally useful on couplings and shafts and it can be made in any length suitable for the work in a particular plant.

All machines should be leveled up. When a set is mounted on a common base, or bedplate, there is always a chance to do the leveling on a planed upper surface of this. Otherwise, one has to clear the shaft of couplings or pulleys and level up by it. It is sometimes possible to provide a foundation sufficiently level so that other checking is not necessary. When a truly level plane has been established in one of the ways named, the only deviation from this will come from wear in the bearings.

On motor-generator sets where the shaft length is above the average, the foregoing check at the couplings does not line up the machines closely enough. It is obviously poor practice to line up a 10-ft. shaft on the periphery of a coupling whose radius is only 7 or 8 in.

Illustration *C* shows a more accurate method of lining from a coupling. The device used consists of two pieces of light steel angles which have one leg of each bent at right angles to form a foot which is attached to the rim of the coupling by two screws. These angles can be any length that will swing without touching the floor or bedplate; long angles will permit making a more accurate check because it is further from the center. Angles are light, stiff, and cheap; an hour's



Where the shafts are over 10 ft. long this type of gage is used at the couplings to check alignment.

work will put these in place and the accuracy of alignment which may be obtained makes them worth more than this slight effort. Also, the angle irons may be kept and used on other couplings and also for periodic checking of the alignment.

If the angles are made the same length, the ends should be squared off so that the test with a steel rule can be made at four points of revolution approximately 90 deg. apart. If one angle is made longer than the other, or the two flanges are not of the same diameter, scriber marks can be made on the longer one and the machines will have to be shifted until these marks made at opposite points finally coincide. The other check to be made with these angles is by use of a feeler between them. This test should also be made every 90 deg. These same tests may be applied to solid flange couplings, although it would be necessary

to loosen or remove the bolts which hold them together.

It might seem that undue emphasis has been placed upon the apparently simple test of checking up at the four 90-deg. points, as indicated in the above paragraphs. However, with electrical machinery, all that there is to work with in most cases is the coupling and it is an impossibilty for two shafts to have these several checks come out right unless the shafts are in line. Hence the method forms a check especially adaptable to such jobs.

For machines having an outboard bearing, it is essential that the shaft be true and its truth known for a certainty. If there is a worn spot inside a bearing or a bend in the shaft, however, all the painstaking labor of lining up will be in vain.

Where it is known that the shafts are perfectly straight and have no worn spots inside the bearings, one of the easiest ways to check alignment of the bearings is to secure a length of shafting of the same diameter and try this in the three bearings, which presumably are of the split type, divided horizontally. With the caps off, a level (having a grooved base) is used at several points to determine the straightness of the shaft as it lies in the cradles formed by the three half-boxes.

The following method of checking against bent shafts assumes that some of the previously mentioned tests for alignment of bearings have been made. Bent shafts are difficult to detect on motor-generator sets and other types of machines with three bearings because of the armatures, rotors, or other parts which are mounted on the shaft. One of the easiest ways to check up a bent shaft in such cases is to secure a length of straight shafting of the same diameter and try this in the three bearings as described above.

The foregoing is one of the easiest ways to check up a bent shaft, either the machine shaft or the length of shafting used for trial purposes. A bend in the piece of shafting will be plainly visible and readily caught if the level be tried on it at one or more points, trying it first "as is" and then trying it as turned over 180 deg. Assuming that it has been found to be straight by this test and the bearings have been scraped or lined up to it, the real machine shaft should lie in the half bearings in the same way and a check with slips of paper or the use of a little spotting material rubbed on the journals would quickly show if there were any bend in this piece.

This special piece of shafting can also be used to spot up the bearings, in the same manner as when bearings are being scraped in. The outboard bearing is shifted, however, instead of being scraped in. If it is possible to turn the machine over (rotate the shaft), its own shaft may be used in much the same way for

spotting as a means of determining alignment; where the journals are of two or more diameters, this will have to be done.

Strips of paper laid under the shaft, when it is raised, will also show a high or low bearing. A strip of paper at each side of the shaft at each bearing will show lack of alignment sideways. These strips should extend in an inch or two between the shaft and its bearing and be pulled after the shaft is lowered again. The necessary adjustments may then be made and these tests repeated until the alignment is perfect.

DONALD A. HAMPSON.

Plant Superintendent,
Morgans & Wilcox Mfg. Co.,
Middletown, N. Y.

Lining Up Conduit on Ceiling Beams

QUESTION.—I wish some reader would please tell me the quickest and proper way to line up ½-in. conduit on the ceilings of mill-type buildings when you are breaking around the beams, using condulet fittings only at the bottom of the beams and also between beams, for lights. Some say it is best to put all of the pipe clips up first by using a chalk line and plumbing down; then you can take the line down and it will be out of the way. Others say to snap the line and take it down, but this method does not make a mark between the beams. As the thickness of the fittings must be taken into consideration, should one go by the edge of the fittings, by the edge of the pipe, or by the center of the pipe? Also, should the clips be put up first? If so, what is gained by so doing?

Worcester, Mass. R. S. T.

ANSWER—Replying to R. S. T., common judgment is to be used in a case like this, taking into consideration the physical conditions of the building in question. There being nothing to prevent, a good way would be to string a chalk line across the ceiling, squaring it with the adjacent walls as far as possible. Snap the line, leaving a chalk line mark underneath each beam. Take a hacksaw and cut a small mark on the edge of the beam, deep enough to be readily seen, but without damaging the beam. Rub a piece of chalk over the cut, and it will fill up with chalk, which leaves a permanent mark that will last for several weeks. It is then an easy matter to string a short line from mark to mark, or from beam to beam, as the work progresses, lining up the conduits with a plumb in each bay or section as these are bolted up.

In this method, after the work is laid out there are no long lines to catch on obstructions or be stretched out of true, and your line marks are there for a period much longer than will actually be needed. Try it and be convinced.

P. S. PENDER.

Chief Engineer,
Metropolitan Eng. Co.,
Granite City, Ill.

Mounting Motors on Ceiling

QUESTION.—In order to get more free floor space we are planning on mounting the motors on the ceiling, above the machines and lineshafts which they drive. I should like to have the experiences of other readers on the following points: (1 The best method of attaching motors to concrete ceilings. (2) What is the best and simplest method of raising and holding motors up until they can be attached? (3) Is there likely to be any more trouble with motors so mounted, than when they are placed on the floor?

St. Louis, Mo. E. H. G.

ANSWER.—Answering E. H. G.'s question, in modern factory buildings it is now customary to have mushroom anchors set in on definite center distances at the time the building is erected, so that you can readily fasten up cross-members to which you can attach your motors, or rails or motor supports.

Motors can also be fastened up by cutting holes through the ceiling. Holes in the floors above should be countersunk deep enough to sink the heads of the bolts flush with the surface and when the motor is in place fill around the bolt heads with cement grout. If the motors are on the ceiling under the roof, you should provide bosses on the roof and cover these with caps to keep out water. These raised bosses should, of course, be flashed to the roofing so that they will be water- and weather-proof.

Motors can be raised by the aid of portable stock tiering or hoisting elevators, or by putting the ends of a wire cable down through two diagonal holes which have been cut for supporting the motor or its mounting and then through the corresponding holes in the motor or motor supports and placing clamps on the cable ends so they will not slide or let the motor drop down.

If the motor has rails it should be bolted to, and lifted by, the rails. Be sure that you have enough hoisting range so that you can lift your motor all the way. If not, provide blocking so that you can hold your motor and get another lift on it by taking the slack out of the cable. When the motor is pulled up, place the nuts on the two free bolts and then remove the cables and drop the last two bolts in place and tightens them up. Be sure to provide locknuts on all holding bolts so that if they should tend to vibrate loose, the motor will not drop.

With the same maintenance you should have no more trouble with motors on the ceiling than on the floor. However, it will as a rule be warmer next to the ceiling, so that the same load will cause a somewhat higher operating temperature. C. N. SHAFER.

Supt. Service Division,
The Lincoln Electric Co.,
Cleveland, Ohio.

How Long Will It Take to Erect These Towers?

QUESTION.—I shall appreciate it very much if some readers can give me the amount of time in man-hours required to erect five steel transmission towers, 9 ft. by 15 ft. at the base and 60 ft. high. I should also like to know the time required to string three No. 3/0 stranded copper cables and one overhead ground wire a distance of 2,000 ft.

Appleton, Wis. M. P.

ANSWER—Answering M. P., the question is rather indefinite as it gives no details as to the nature of the ground, present location of towers, whether the towers are already fabricated, whether foundations are already in, voltage, type of insulators, and so on. All of these points and many others would affect the cost of erecting the towers and putting the line in commission. Another point to consider is the previous experience of the erection gang in similar work, and the kinds of tools and equipment available. The erection of 2,000 ft. of line is quite different from erecting a line several miles long where the crew, even if they are comparatively inexperienced to begin with, will gain considerable proficiency in the work before many miles have been covered.

The best criterion for the cost of a job of this kind is reliable cost data secured from similar jobs. I have some figures covering the cost of a transmission line recently erected in the Middle West where unit labor cost would be the same as in M. P.'s territory. This was a 132-kv. line about 40 miles long. Double-circuit steel towers were used, having the approximate dimensions given by M. P. One circuit only was installed, using No. 3/0 steel-reinforced, aluminum conductor. The towers were assembled on the ground in a horizontal position and erected by means of a gin pole, block and tackle and a 2-ton tractor. A summary of the labor cost per mile of line, exclusive of trucks, freight, board, lodging, testing, tools, damages and miscellaneous was as follows:

(*a*) Clearing	$244.00
(*b*) Foundation	1,181.00
(*c*) Assembling towers	311.00
(*d*) Erecting towers	165.00
(*e*) Stringing wire	130.00
(*f*) Unloading and hauling	80.00
(*g*) Engineering and supervision	240.00
Total	$2,351.00

All of the above items, and especially item (*b*) were heavy because of the swampy nature of the ground. At this same rate a 2,000-ft. line would cost about $900 to put up, but it must be remembered that a small job

cannot, as a rule, be handled as cheaply as a large one, on which everything is well organized.

In several other similar jobs the cost of erecting towers has gone as low as $95 per mile and from that on up to $165, as given above. The labor cost of stringing wire has been found, under favorable conditions in this class of work, to go as low as $40 per mile of conductor, or $120 per mile of three-phase line. Under unfavorable conditions, it may go as high as $80 per mile of conductor.

Another example may be given of a 66-kv. line, 33 miles long, using steel poles 3 ft. 6 in. square at the base and 60 ft. high, carrying two No. 1/0 stranded copper circuits on suspension insulators. These poles were considerably smaller than those used in the first example. The labor cost per mile of line is open, level country with 500- to 700-ft. spans was as follows:

(*a*) Digging holes and placing foundations...	$212.00
(*b*) Distributing material	77.60
(*c*) Bolting up and erecting poles	99.20
(*d*) Stringing wire	141.20
(*e*) Miscellaneous	44.80
Total	$574.80

These two examples probably represent maximum and minimum cost for jobs of this character. Cost data from any one job should not be applied indiscriminately to any other job unless all governing factors are identical in all respects. Of course, this condition never exists in practice; so the best M. P. can do is to study the above and similar data and apply them to his job. E. I. PEASE.

Ford Worden, Wash.

Supporting Load from Concrete Ceiling

QUESTION.—In rearrangement of the plant with which I am connected, we frequently find it necessary to suspend conveyors, motor platforms, countershafts, heavy radiators, and similar equipment from the ceiling of a reinforced concrete building. I am wondering if any of the readers have any information on how heavy a load can be supported from expanded bolts. I would also like to find out what other readers consider the best method of fastening equipment to the ceiling.

Chicago, Ill. E. D. F.

ANSWER—In answer to E. D. F.'s question, the literature on the holding power of expansion bolts set in concrete is quite limited. Merriman, in his "American Civil Engineer's Pocketbook," third edition, page 591, states that expansion bolts, when imbedded in 1:2 portland mortar, have an ultimate holding power of 264 lb.

per sq. in., and adds that a working unit stress of about one-fifth of this, or 53 lb. per sq.in. should be used.

Turneaure and Maurer in their "Principles of Reinforced Concrete Construction," second edition, page 216, state that the bond strength of plain steel is 200 to 250 lb. per sq.in., from which a working stress of 60 to 80 lb. per sq. in. is suitable. They further state "For deformed bars having a positive grip, a working stress of 150 lb. per sq. in. gives an ample margin of safety."

Let up apply this to a particular brand of ½-in. bolt and anchor. Roughly, the anchor is 1 in. in diameter and 2 in. long, making an area of 6.28 sq. in. imbedded in concrete. At 150 lb. per sq. in. this would give a holding power of 942 lb. Allowing 10,000 lb. per sq. in. tensile strength in the bolt, which ought not to be exceeded, a ½-in. bolt is good for 1,260 lb. in tension. This would show that, for this particular case, the anchor would be weaker than the bolt.

There are a number of types of expansion shields on the market, ranging in size from those for small wood screws to those for 1-in. bolts. Each manufacturer claims that his particular product is the best and asserts that when properly applied the bolt will break before the anchor pulls out. This may be true in all cases where properly installed, but unless the workman is thoroughly familiar with this class of work, the shields will not be properly installed. This is especially true of the malleable and composition anchors on the market. Proper drill size is absolutely necessary for the correct installation of these anchors. The "Pierce" lead sleeve expansion bolt comes in sizes of ¼ in., ⅜ in., and ½ in. and of varying lengths and has been found to be very effective in these sizes. For bolts larger than ½ in., malleable anchors of either the "Sebco" type or the "Keystone" type have been used here with success. The latter has been used to support 1-ton trolley tracks mounted on a concrete ceiling.

Practically, I should hesitate to depend upon an anchor's developing the same strength as its bolt and, to allow for poor workmanship, would say that no anchor should be called upon to develop more than one-half of the working strength of the bolt.

E. I. PEASE.

Fort Worden, Wash.

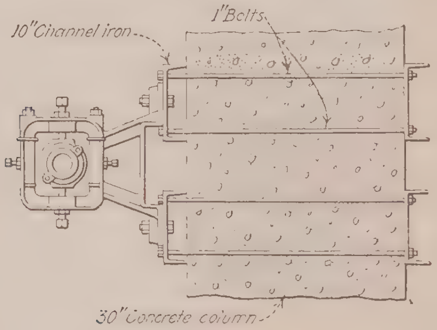
Supporting Lineshafting on Concrete Pillars

QUESTION.—I have to support several long runs of lineshafting on concrete pillars and should like to know (1) if this is considered god practice. (2) Will it be necessary to use adjustable pillow blocks, or will the solid type be satisfactory? (3) Is there enough danger of the pillars settling or getting out of line to make it necessary to brace these in any way?

Brooklyn, N. Y. C. R. P.

ANSWER—Referring to C. R. P.'s inquiry, it is common practice to support long runs of lineshafting on concrete pillars and this should give excellent results if the weight of the shaft and belt pull are not out of proportion to the size of the pillars. Most heavy lineshafts are supported in wedge-base, self-aligning pillow blocks on concrete piers installed especially for this purpose, but judging from the remark about bracing them, I judge C. R. P.'s pillars are building members, in which case they will probably be stiffer than any bracing that could conveniently be applied.

For supporting moderate-sized shafting—up to $3\frac{7}{16}$-in. or thereabouts—on rectangular concrete posts, we have found the arrangement shown in the illustration to be



Bracket hangers may be conveniently supported on channel irons bolted to concrete columns.

cheap, convenient to erect and very satisfactory in operation. The size of the channel iron must be proportioned to the size of the shafts and the width of the column, but for $3\frac{7}{16}$-in. shafts and a column width of 30-in., a 10-in. channel iron is about right. The channels are cut about 6 in. longer than the width of the post and drilled so as to bring the bolts close against the sides of the posts. Under the above conditions, use 1-in. bolts. Filling the space between the channels and the post with a heavy grout thoroughly packed in is important as it not only increases the bearing area and prevents the edges of the channel cutting into the post but materially stiffens the web where the hangers are bolted.

Adjustable bearings are essential, as it would be practically a hopeless and endless job to line up a long shaft by shimming out solid boxes and jacking them into line.

Settling or leaning of posts, buildings or any other form of structure is altogether a question of foundation, which must be of sufficient area not to exceed 2 tons pressure per sq.ft. on any part of the area, and less

on loose, sandy soil when the structure is subject to vibration. The foundation must be carried down below the frost line and preferably should go down to solid soil. If this is impossible the solidest spot available must be chosen and the base area increased correspondingly. Settling is bound to occur if an attempt is made to build on recently filled-in soil. In such case, driving piles to a firm bottom is the only way of getting a satisfactory job.

H. D. Fisher.

Plant Engineer,
New Haven Pulp & Board Co.,
New Haven, Conn.

How Should This Machine Be Placed?

QUESTION.—It is common practice to place a pulley at right angles to a lineshaft which, of course, means that the belt has no twist in it. However, we have a 125-ton press and would like to place it in such a position that the pulley on this press will be 45 deg. from the lineshaft. I should like to know, (1) if this is an unusual way of running a belt, and (2) how should the machine be placed with the pulley in this position, so that the belt will not be continually slipping off.

Philadelphia, Pa. A. T. S.

ANSWER—Replying to A. T. S., (A) in the illustration shows the relative location of the shafts, pulleys and belt. Also, (SP) represents the lineshaft pulley and (MP) the machine pulley, the center lines of whose axes lie in different horizontal planes, but at an angle (x) instead of being parallel, as is usually the case. It is possible, and practicable, to install pulleys for any value of (x) between zero and 180 deg., provided the shaft centers are sufficiently separated.

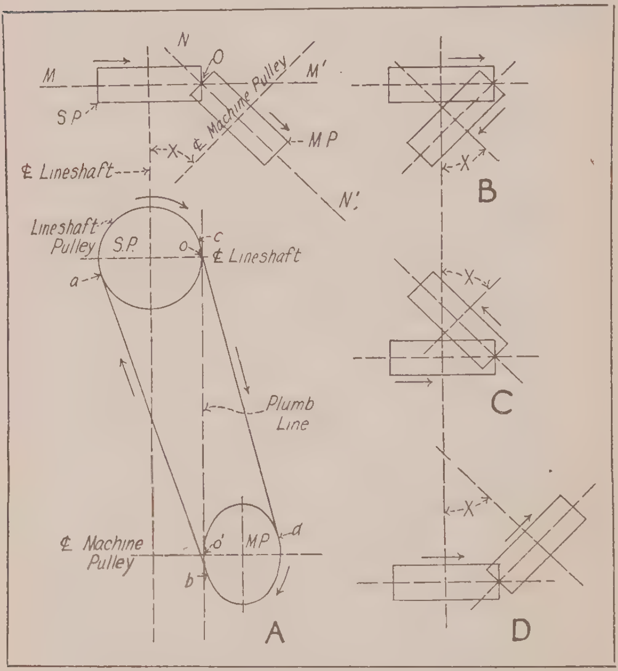
For successful operation it is essential that plane (MM′) of the lineshaft pulley and plane (NN′) of the machine or driven pulley intersect so that points (b) and (c) will lie in both planes. Point (b) is the point of tangency between the belt and the machine pulley where the belt leaves the pulley. Point (c) is the corresponding point of tangency on the lineshaft pulley.

It can be stated, in general, that the point on a pulley where a belt leaves it must be so located that the belt will be delivered to the center of the face of the receiving pulley. If this condition is rigidly adhered to there will be no difficulty in installing pulleys at any angle, provided the centers are sufficiently spaced and the shafts do not lie in the same plane. From this it is evident that in a given installation the direction of rotation of the pulleys is not reversible.

If the pulleys are both very nearly the same size the approximate location can be determined by dropping a plumb line from point (o) on the lineshaft pulley and placing the machine pulley tangent to the plumb line. In order to get the exact location it may

be necessary to move the machine a little to compensate for the slight differences in position of points (o) and (c) and (o′) and (b) on the pulleys.

For each angle (x) there are four possible positions in which the machine or driven pulley may be placed relative to the lineshaft pulley. In two of these posi-



Relative location of shafts, pulleys and belt when the axes of the shafts lie in different horizontal planes and at an angle to each other.

tions the machine pulley will be driven in one direction and be reversed in the other two positions. In the illustration (B), (C) and (D) show the three positions and direction of rotation not shown in (A).

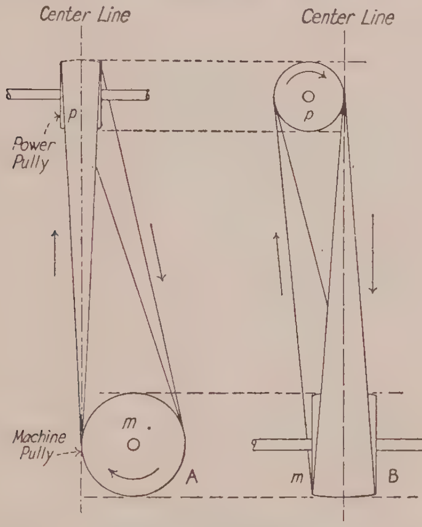
It should be noted that the point at which the belt leaves the pulley is a controlling feature in installations of this sort. If attention is paid to this no trouble should be encountered in the solution of the problem.

CHAS. R. SUGG.

Wilmington, N. C.

ANSWER—In answer to A. T. S.'s question, almost any machine can be placed at an angle of 90 deg. or less away from the power lineshaft, providing that the belt is properly lined up to both pulleys. In the first place, note the direction of the power pulley (P), in the illustration (A), then drop a plumb line off its periphery **toward** which the belt is traveling.

The machine pulley (M) must then, if turned at 90 deg., have its periphery just touch the plumb line.



Method of lining up lineshaft and machine pulleys when shafts are at right angles.

It will be noted that as the belt is traveling from the machine pulley (M) up toward the power pulley (P) it approaches the latter along a perfect center line, which is correct.

Now, the slack side of the belt, going downward from the power pulley and approaching the machine pulley, must travel along a line at right angles to the shaft of the machine pulley, see illustration (B), so as to ride upon the latter on the face center.

This adjustment may be rather difficult if the machine cannot be shifted into line, but easy if it can be. However, a plumb line or straight edge extended upward from the face center of the machine pulley, should just touch the periphery of the power pulley, as in (B).

If the direction of the lineshaft is reversed from this diagram, the pulleys must be lined up in other positions, as that side of the belt **approaching** each **pulley**

must be on its center line, and not approach it from an angle. However, the belt can leave each pulley at an angle, with no bad effects.

If pulleys and belt are properly lined up to a machine at any angle up to 90 deg. from the power shaft, no guides will be required to keep the belt on the center of the crowns, for it will ride there perfectly. If it does not, the lining up was faulty.

Any ratio of pulley diameters may be used.

H. S. RICH.

New Britain, Conn.

Trolley Wire Supports for Monorail Crane

QUESTION.—I have a monorail crane running on an I-beam, which has to travel around two rather sharp bends, and wish that someone would give me his experience as to the best way of installing and supporting the two trolley wires that feed this crane. How should I support the wires where they go around the bends?
Barre, Vt. C. G.

ANSWER—In reply to the question by C. G., the use of trolley wires around curves on crane tracks is very troublesome. We have found that the tee bar system is by far the best to use under these conditions.

If $1\frac{1}{4}$-in. tee bar is used it can be bent cold to fit almost any bend or angle that may be required. The tee bars should be held in place by $1\frac{1}{2}$-in. by $\frac{1}{2}$-in. angles clamped to the top of the I-beam.

At the proper distance apart, equal to the distance between the collector shoes on the hoist, two $\frac{3}{4}$-in. holes should be drilled in each angle. Into these holes a piece of fiber tubing $\frac{3}{4}$ in. in diameter with a $\frac{1}{2}$-in. hole should be placed, and cut off flush with both sides of the angle. On the same side of the angle, two $\frac{7}{16}$-in. holes should be drilled for supporting the clamps by which the angle cross-member is fastened to the I-beam. For a 5-in. beam we drill these holes $6\frac{1}{4}$ in. apart. For the clamps we use a piece of steel $\frac{1}{4}$ in. thick and $1\frac{1}{2}$ in. long. By placing a $\frac{1}{4}$-in. offset in this piece, drilling a $\frac{7}{16}$-in. hole in the end and placing this clamp against the underside of the top of the I-beam, and bolting to the crossarm, a very rugged support can be made.

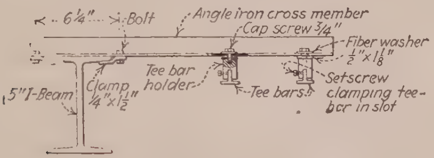
For the tee bar holder a piece of steel 1 in. square and $1\frac{1}{2}$ in. long is used; a hole is drilled in one end and tapped for a $\frac{1}{2}$-in. capscrew. In the other end a slot is cut $\frac{1}{4}$ in. wide and $\frac{3}{4}$ in. deep. In one side, opposite the slot, a hole is drilled and tapped for a $\frac{3}{8}$-in. setscrew for holding the tee bar.

When mounting the tee bar support to the crossarm a fiber washer $\frac{1}{8}$ in. thick and $1\frac{1}{8}$ in. in diameter with a $\frac{1}{2}$-in. hole in the center, is placed between the tee bar support and the crossarm. Another washer of the same size is placed on top of the angle-iron crossarm. A $\frac{1}{2}$-in. capscrew with a flat iron washer is then screwed

through the washers, bushing, and into the tee bar support; this prevents any danger of grounding. This method of supporting tee bars indoors has proven a success with us; for outdoor service we use a porcelain support in the same way.

For collecting the power from the tee bar we use a shoe made by the Shepard Electric Crane & Hoist Co., Montour Falls, N. Y. These shoes are designed to take care of any uneven joints and also any side motion caused by swinging loads, and to keep a constant pressure against the tee bar. On our hoists which operate on very sharp curves we use a wider shoe; this gives us greater contact when the hoist first starts to make the curve.

The operation of a medium-sized hoist, with a capacity ranging from 2 to 6 tons, operated on curved



This shows how the tee bars are supported from a crossarm mounted on top of the I-beam.

I-beams continuously, means a very heavy maintenance cost, owing to the fact that as soon as the loaded hoist enters on the curve it must change the direction of the load. This causes a side strain on the hoist, causing the wheels to bind against one side of the I-beam. In a short time this cuts the flange of the hoist wheels to such an extent that if the wheels are not changed at regular intervals climbing of the wheels on the I-beams will be experienced on the curves, thereby permitting the opposite wheels to wedge against the I-beam flange and stick, making it necessary to rock the hoist back and forth on the beam. At the same time, the I-beam cuts very fast, shortening the life of new wheels and in due time replacing of the beam is required, which is a costly operation.

In view of this we have adopted the plan of fastening a 16-lb. rail to the lower flange of the I-beam by means of the Shepard rail clamp, which does not require any drilling of the I-beam for supporting the rail. When replacements are necessary it is much cheaper to change a rail than a curved I-beam. Also, as the rail has a much wider surface bearing against the flange of the wheel on curves, the life of the wheel is prolonged.

At present we are operating several hoists on the above system 24 hr. a day, under severe duty, including side lifts and overloads. The delays and repairs are

very low, considering the service we get from the hoists.

I hope that the facts and suggestions given above will be of help to C. G. N. H. CASE.

Chief Electrician,
Wyckoff Drawn Steel Co.,
Ambridge, Pa.

How to Support a Mule Stand

QUESTION.—We are planning on a lineshaft installation in which it will be necessary for the shaft to extend across the room, with an additional section to be installed at right angles along the side wall. We have been considering using a mule stand but some of our men who have had experience with this device in other shops advise going to the expense of separating the shafts and using two motors.

I should like to know the methods other readers have used in supporting such stands and lubricating the pulleys and the results they obtained. This is a mill-construction building with a $2\frac{15}{16}$-in. main shaft and a $1\frac{15}{16}$-in. shaft on the extension.
Milwaukee, Wis. R. C. A.

ANSWER—In answer to R. C. A.'s question, I would say that he seems to have touched on the two most important points when he mentions the support and the lubrication. When properly installed and maintained there is no reason why that type of drive should not be satisfactory in every way; if, however, certain points are neglected the mule drive can be just as cantankerous and stubborn as its more famous namesake is credited with being.

The accompanying sketch shows one of many such drives which I know from experience are giving no trouble whatever and are almost noiseless in operation. The only attention required is to screw down the grease cups daily.

The main points considered in the layout and installation of this drive are its supports and lubrication. Figs. I and IV show how the mule stand is supported and braced. The arbor *a* is threaded into a 10-in. flange, *b*, which is bolted onto the bottom side of a 10-in. by 12-in. timber. The guy rods, *c* and *d*, with turnbuckle adjustments are attached to the bottom of arbor *a* to counteract the belt pull. This might appear to be an unnecessarily heavy and rigid support for a light drive, but the worst enemy of the mule drive is vibration and the more vibration can be eliminated, the better the drive will operate.

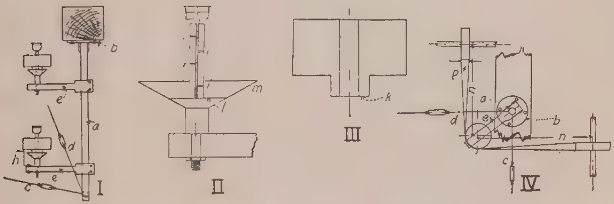
The other important factor, lubrication, is taken care of in this particular drive by grease cups which force common grease into the end of a hollow shaft and out through small grease holes, as shown at *i*, Fig. II. The bottom of the pulleys, Fig. III, is finished as shown at *k* and is supported by the bottom *l* of the cup *m*; this cup also helps to retain the grease which is forced

down through the hollow shaft and under the pulley by the grease cup above.

This method of lubrication is quite satisfactory for light drives. These sketches show a drive with a $2\frac{15}{16}$-in. main shaft and a $2\frac{7}{16}$-in. cross-shaft with a 4-in. belt. The mule pulleys operate at 600 r.p.m. For a heavy drive, however, where it is necessary to use a 10-in. or a 12-in. belt, roller bearings should be used on the shafts and ball-thrust bearings under the pulleys.

There are a few other points which will also make for satisfactory operation: one of these is to fasten a support, *h*, Fig. I, to the end of the arm *e* which carries the pulley on which the slack side of the belt runs when the load is applied. When this is not done a sudden load will often cause the belt to drop off, although it takes very little to support it.

It is also good practice, wherever room permits, to make the distances *n*, Fig. IV, between the centers of the pulleys and the centers of the driving and of the driven shafts, a number of feet which will be at least



Construction, bracing and method of lubricating a mule stand drive for a 4-in. belt with the mule pulleys operating at 600 r.p.m.

twice the width of the belt in inches; thus, for a 6-in. belt the distance between shaft centers should be 12 ft. The reason for this is that the belt is twisted one-quarter turn and if that quarter twist is taken in too short a distance the life of the belt will be considerably shortened and the drive will tend to give more trouble through vibration. J. H. GALLANT.

Belleville, Ont., Can.

Removing Concrete Foundations by Blasting

QUESTION.—We want to remove the foundation of a large engine and I should like to have the experience of other readers in removing foundations by explosives or in other ways. How can I keep down the concrete dust while drilling the foundation? If we blast the foundation how can I keep pieces from flying and damaging nearby machines? Will it be necessary to take the windows out? What explosive works best and how much should be used for a shot? I shall appreciate any suggestions you can give me.
Detroit, Mich. A. H.

ANSWER—In reply to the inquiry by A. H. a short time ago we removed a large concrete engine foundation by blasting and the method used was as follows:

Starting at the edge of the foundation and about 1 ft. in from the edge we drilled a series of holes approximately 2 in. in diameter and 18 in. deep, spaced about 3 ft. apart. We used a pneumatic rock drill for putting down the holes and 2 min. was about the average time required per hole. Ordinary black powder was used. The size of the charge used was from one to two ounces. This can be determined to suit conditions by starting with a very small charge and increasing until the desired effect is produced. The holes were blown out with air after drilling, and the charge placed in the bottom of the hole. A wad of paper was rammed on top of it and then the balance of the hole filled with earth, well rammed. We have tried both the time fuse and the electric fuse and find the latter much to be preferred.

We always have plenty of old fibre cartridge fuse cases around and we utilized these for the charges. A fuse was made up by twisting two No. 16 fixture wires together, the pieces being about 10 ft. long. The wires at one end were joined by a piece of 2-amp. fuse wire about 1 in. long; the other ends of the wire were joined to a flexible cord with a plug at the end to fit a standard lamp socket. The end with the fuse wire attached was inserted in one end of the old fuse shell by removing the cap at one end. The powder charge was then poured in and after making sure that the fuse wire was covered by the powder, the end of the shell was plugged with paper.

After the charge was in place and the hole plugged a mattress was placed over the hole. This mattress consisted of a light wood frame covered with several thicknesses of burlap. In size it was about 8 ft. square. We held the frame down by placing a few sand bags along the edges. The charge was exploded by screwing the plug into convenient lamp socket and turning on the current. The plug should be removed after each "shot" for safety to prevent the possibility of a premature discharge through someone accidentally turning it on.

The burlap mattress will keep the pieces from flying and if wetted will stop most of the dust. If the shots are gaged right there will be no necessity of removing the windows.

We blasted for a week in one of our departments which was in full production, and had no trouble whatsoever, with holding up of production, broken glass, damaged machinery or personal injury.

L. J. CLAYTON.

Ass't. Mechanical Engineer,
The Goodyear Tire & Rubber Co. of Canada, Ltd.,
Bowmanville, Ont., Can.

Proper Foundation for Alternator

QUESTION.—(1) We are going to install a 133-kva., belt-driven alternator in the near future, and I should like to know how to make a suitable foundation for it. We are thinking of using a wooden framework. Is this alternator too large for such a foundation? I should like to know what type of foundation readers would recommend for this alternator, and also how the foundation should be made. (2) When the distance between pulley centers of the alternator and engine is long should the alternator foundation be heavier than when the machines are close together? How should the alternator be fastened to the timbers or other types of foundations that are recommended? I shall greatly appreciate any information that readers can give.

New Orleans, La. O. C. H.

ANSWER—Referring to O. C. H.'s inquiry regarding the foundation for a 133-kva., belt-driven alternator, I would say that the data furnished are rather indefinite as to the speed, pulley size and location, although some general information may be of assistance.

Unless local conditions make concrete or brick foundations impractical, I would not recommend a wood foundation as it is hard to get a good level bearing without the use of loose wedges. The softness and give in wood, together with a continued drying process, make it difficult to keep the machinery tight on the foundation and thus prevent vibration. Most of the motors up to 125 hp. that we have mounted on wooden foundations have been installed only for temporary service. As he wood shrinks and wears down, it will be necessary to tighten the foundation bolts periodically, in order to prevent the machines from vibrating. A belted machine should be installed on a sliding base so that the belt may be conveniently tightened, when necessary.

If the foundation is to rest on earth, I would recommend a concrete foundation which is about 1 ft. larger than the base of the machine. The base of the foundation should be set into the earth about 3 ft., of if there has been a recent fill dig down to solid earth. The top of the foundation should be built about 1 ft. above the floor level in order to keep the machine up out of the dirt and wet.

The lower end of the foundation bolts should not only have washers but should extend to within 6 in. of the bottom of the foundation. The upper end of the bolts should extend through a pipe sleeve that is about 1 ft. long and 2 in. larger in diameter than the bolts. After pouring the foundation, the sliding base and machine should be set in the operating position and leveled high enough with iron wedges so that there will be plenty of clearance for about 1 in. of grouting. After lining up the machine, the base should be grouted in, being careful to fill in around the founda-

tion bolts, in order to keep the base from shifting sideways.

It does not take an enormous foundation to withstand the belt pull of a motor or generator, but it is important to have the machine bolted down securely so as to prevent vibration.

Due to the fact that the arc of contact between the pulley and the belt is greater with a long belt than with a short one, it is likely that the total belt pull is slightly less with a long belt. Generally the difference in belt pull is not great enough to materially alter the size of motor foundation.

In fastening the alternator to the foundation, as has been described above, a standard sliding base as furnished by the maker should be used. Whether the foundation is of wood or concrete, through-bolts should be used in preference to lagscrews. In the event that a wooden foundation is used, through-bolts should be employed so that the foundation can be tightened up when necessary.

Much trouble with motors and generators can be eliminated, if a little more care is exercised when the machines are installed. H. D. FISHER.

Plant Engineer,
New Haven Pulp & Board Co.,
New Haven, Conn.

Determining Horsepower of a Shaft or Clutch

QUESTION.—Manufacturers of couplings, clutches and other transmission equipment rate their equipment in horsepower per 100 r.p.m. Thus a device that will transmit 10 hp. at 100 r.p.m. would transmit 25 hp. at 250 r.p.m. I understand clearly that the horsepower per r.p.m. is the same in both cases. However, it seems to me that the shock to both clutch and lineshaft caused by operating a clutch at 250 r.p.m. would be so much greater than at 100 r.p.m. that a heavier clutch would be required. I should like to get the opinions of readers on this point. In particular I should like to know what allowances, if any, they make for clutches and other power transmission equipment operating at speeds higher than 100 r.p.m.
Grand Rapids, Mich. E. E. H.

ANSWER—In reply to the recent question by E. E. H., the items of excessive wear due to high speeds and shock of starting are considered when determining the horsepower of a lineshaft or clutch, or at least they should be, when figuring the power for high speed, and a liberal allowance made. For shafting the use of formulas is recommended. Shafting transmitting torque may be divided into three classes according to the kind of stresses to which they are subjected:

(1) Shafts subjected to torsion.
(2) Shafts subjected to bending.
(3) Shafts subjected to torsion and bending.

Due consideration must also be given to shaft de-

flection both angular and linear, or in other words the shaft must be stiff enough for the purpose. In calculating shafting for pure torsion it is customary to use the following unit stresses:

Main power shafts—4,000 lb.

Line shafts with pulleys—6,000 lb.

Small short shafts, torsion only—8,500 lb.

The inch-pounds torque may be calculated from the following formula:

(1) $Hp. \times 63{,}025 \div r.p.m. =$ In.-lb. torque.

The size of shaft may then be determined as follows:

(2) (In.-lb. torque) $\div (0.196 \times d^3) =$ Unit stress.

The above two formulas may be combined into one formula which will shorten the time of calculation:

Main power shafts, $Hp. = (d^3 \times r.p.m.) \div 80$.

Lineshafts with pulleys, $Hp. = (d^3 \times r.p.m.) \div 53$.

Small, short shafts, torsion only, $Hp. = (d^3 \times r.p.m.) \div 38$.

No allowance is made for the weakening of the shaft by the cutting of a keyway. Keyways reduce the strength of a shaft in torsion about 18 per cent.

Shafting with bending stresses is calculated first by determining the bending moment and torsional moments separately, combining the two into one stress called "equivalent twisting moment," and then substituting this value in formula (2) as in.-lb. torque.

(3) $T_0 = M + \surd\ (M^2 + T^2)$

Where: T_0 = Equivalent twisting moment; M = Bending moment; T = Torsional moment. Assuming stresses of 6,000, 8,000 and 10,000 lb. per sq. in. is common practice in calculating equivalent torsional stress in shafting.

Shafting should not have an angular deflection of more than 1 deg. in 20 shaft diameters. It is good practice to add $\frac{3}{8}$ in. to $\frac{5}{8}$ in. to the shaft diameter for angular deflection.

$(583 \times T \times L) \div (D^4 \times G) =$ Angular deflection. Where: T = Torsional moment; L = Length shaft twisted in inches; d = Shaft diameter in inches; G = 12,000,000.

Shafting may also be subjected to linear deflection and when the stress is exactly between the two bearings the deflection may be calculated with the following formula:

[(Load in pounds) $\times$ (Span in inches)^3] $\div$ [48 $\times$ 29,000,000 $\times$ (Moment of inertia)] = Deflection.

According to good practice, shafting should not have a linear deflection of more than 0.01 in. per foot of length.

The use of a brake test is recommended to find the load that will slip the clutch at a given pressure per square inch of friction surface. This pressure varies

from about 10 lb. to 100 lb. per sq. in. The greater the pressure the shorter will be the life of the friction material and other parts of the clutch. A pressure of 25 lb. per sq. in. is recommended for clutches of the type used with general transmission machinery.

The load required to slip the clutch can be determined with a prony brake or by securing the clutch to a stationary shaft having an arm attached to the loose member of the clutch and the weight hung from the end of the arm. After the shaft and clutch are ready for the test, arrange to have the right pressure applied to the sliding collar, when placing the clutch in gear to get the required pressure on the friction surface. After finding the weight that slipped the clutch, proceed to figure the power as follows. Assume that the lever is 4 ft. long, measuring from the center of the shaft to the center of the weight suspended on the end of the lever. The circumference of a 4 ft. radius will be 25 ft., less the fraction. Suppose the result of a test made with a 4 ft. lever showed that 300 lb. weight was required and say the speed of the clutch was 100 r.p.m. Assume, A = Circumference (approximately 25 ft.); B = Weight (300 lb.); C = Revolutions (100 r.p.m.). Then $(A \times B \times C) \div 33{,}000 = 22.91$ hp.

For those wishing to arrive at a safe rating for various speeds and figuring from the rate given at 100 r.p.m., starting with a speed of 200 r.p.m., a clutch having 10 hp. at 100 r.p.m. will have 20 hp. at 200 r.p.m. From the 20 hp. deduct 5 per cent. The power at 250 r.p.m. will be 25 hp.; from this deduct 10 per cent. For the next increase of 50 r.p.m. the deduction will be 15 per cent. Continue in the same manner to speed limit.

There are conditions that cannot be taken care of by the instructions given, such as heavy starting loads, pulsating loads, continuous service, and clutch to be placed in and out of gear at short intervals. For extreme conditions the information should be given to a competent engineer to decide the power of the clutch required to obtain good service. J. L. LEMLY.

Manager, Clutch Department,
W. A. Jones Foundry & Machine Co.,
Chicago, Ill.

Card System for Miscellaneous Power Drive Equipment

QUESTION.—The only storage space we have for miscellaneous pulleys, shafting hangers and similar parts is some distance from the room which serves as the repair shop and headquarters of the maintenance department. As we now have no system of keeping track of this material one of the men must go and search through if whenever anything is needed. I should like to know if any reader has worked out a

card system that we could use to tell what we have on hand.
Kansas City, Kan. H. L. G.

ANSWER—Replying to H. L. G., we use the card shown in the illustration for keeping a record of miscellaneous pulleys. These cards, which are standard 3-in. by 5-in. index cards, are made out by the head of the maintenance department and kept in his files. If there is on hand only one pulley of a particular size, a new card is made out when the pulley is sent to the stockroom. When the pulley is taken out of stock, the card is destroyed.

If there is more than one pulley of the same size on hand, the number shown on the card is altered each

MAKER	DODGE MFG. CO.				
Style	"STANDARD" IRON SPLIT.				
Diameter	29"	Face	4" CROWN	Bore	3 7/16"
Keyway		Setscrews	2 - 5/8"		
No. on hand	6				
Location	STOCKROOM.				
Remarks	OLD LOOM DRIVE PULLEYS.				

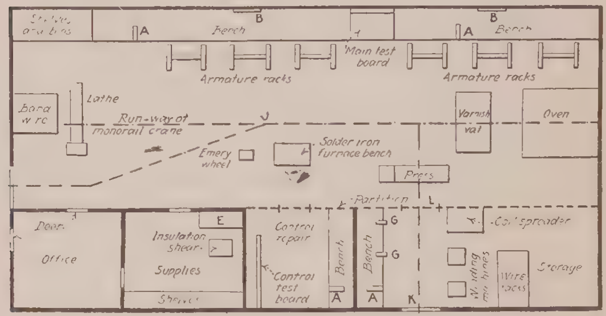
Record card for keeping track of the number and types of spare pulleys in stock.

time a pulley is put into or removed from stock. I believe this card could be improved by adding the words Flat and Crown, one of which could be crossed out as needed. DONALD MAXFIELD.
Guilford, Me.

Laying Out Electric Repair Shop for Steel Plant

QUESTION.—We are planning to build a new shop for doing our electric repair work. This shop will handle the necessary repairs on motors and control in a steel plant having about 1,000 modern motors both a.c. and d.c. During normal operation 14 men are required in the shop. Naturally the shop will have a coil-winding section; so provision must be made for winding equipment and supplies. In addition there will be a lathe, insulation cutting shear, baking oven, armature press, test rack and other shop equipment. I would like to obtain the views of readers as to what would be the most practical layout of a repair shop for this class of work. Possibly they have found certain arrangements of repair shop equipment that have produced money-saving results.
Indiana Harbor, Ind. A. R. D.

ANSWER—In answer to the question by A. R. D. I would like to offer the accompanying sketch of a shop layout, which combines the best points of several repair shops that I have seen. In this sketch the dotted line is a partition which may or may not be put in, according to the ideas of the management. I believe, however, that it will pay to put it in because of the fact that each department is thereby isolated and the distractions due to testing will not affect any other department.



Due to the convenient arrangement of equipment, this electric shop layout will save time of workmen and speed up repair operations.

A in the sketch represents a bench vise, four of which are shown; of course, it is not absolutely necessary to have this number, but they will save time, when installed at the positions shown. *B* is a small testing board which consists of a buzzer with series test leads; four pony receptacles, wired series-multiple; and series-test leads for testing d.c. armatures with a telephone receiver, if this method is to be used. All high-voltage tests will be made at the main test board which should be arranged so that 5,000 volts a.c. may be obtained for ground tests on 2,200-volt equipment. Likewise, a.c. and d.c. voltages should be on the board to test motors used or repaired in the plant. A large growler should be suspended overhead for testing d.c. armatures for shorts and partial shorts. The emery wheel stand and bench for supporting the furnace for heating soldering irons are shown in a central location. *E* is an insulation rack in front of which is the insulation shear (note that this shear is in the supply room). A man or boy should be in charge of this supply room, who is capable of cutting insulation to winders' measurements and the cutting waste should be used on small jobs. This man can, in his spare time, also lay in a stock of insulation cut to the sizes most frequently used. *G* indicates taping machines for coils.

A monorail, shown here in dotted lines, with two 1-ton blocks will be necessary. It will be advisable to put a switch in this monorail, as shown at *J*. *K* is an outer door which should be able to accommodate with plenty of clearance, the largest apparatus which has to be repaired. *L* is a small door in the coil department for the convenience of the men who strip and clean coils that are to be rewound. Small stators can also be burned out conveniently in this part of the shop. One or more racks should be provided for coils that are to be dipped. These coils can be handled by the chain block on the press monorail and shunted to the main monorail by aid of another block. The band wire is racked behind the lathe entirely out of the way. Unless the lathe is reversible, one or more rollers will be necessary on the apron to bring the wire to the front for banding.

The shop should be well lighted, warm in winter and as cool as possible in summer. Winding is tedious work under the best conditions and the nearer ideal conditions are obtained, the greater the capacity of the workmen. Six armature racks are shown, which should have rollers about 4 in. in diameter and should be adjustable as to length. One or more heavy tables should also be provided for supporting stators while being rewound. GRADY H. EMERSON.

Birmingham, Ala.

What Shop Equipment Will Be Required Here?

QUESTION.—I would like to have some of our readers tell me what equipment they think will be necessary for a shop to handle a general motor repair business in a city having a population of 50,000. I wish to have as completely equipped a shop as is consistent with the amount of repair work that I may expect to do in a city of this size. Any recommendations as to kinds and makes of equipment necessary, will be very much appreciated. Also, I should like to know what kinds and amounts of supplies, such as insulated wire, insulation, varnishes, tapes, etc., should be carried in stock.

Pedro Miguel, Canal Zone. P. F. W.

ANSWER—Answering P. F. W.'s question, a great deal would depend upon the size and type of machinery used in this town, and whether the power supply is mostly alternating or direct current. I presume that it is alternating current. The average contracting shop for repairing motors, transformers, and control equipment is established in a building approximately 60 ft. by 80 ft.

Regarding the selection of equipment, the following suggestions are offered: He will need a lathe with at least a 9-in. swing, which will permit rotors or armatures of about 18 in. diameter to be handled. A grinder

with fine and coarse wheels about 8 in. in diameter and a small power drill for taper-shank bits, with an adjustable, round shank for small drills, will be needed. Coil winding equipment which may be obtained with the motor attached is the most suitable because there are no lineshafts or belts to install. At least one taping machine will be necessary. I would recommend the coil winding machine and attachments invented by S. H. Browning and manufactured by the Mutual Foundry Co., Atlanta, Ga. This company also makes a coil spreader. These machines are used by many electrical repair shops and are advertised in INDUSTRIAL ENGINEER.

For dipping and baking, a sheet-iron tank about 2 ft. deep by 4 ft. wide and 6 ft. long, will be found suitable for this purpose, although the dimensions may be altered as necessary. I would recommend a ventilated oven about 6 ft. long, 5 ft. wide and 5 ft. high, built of brick or some other insulating material. This oven may be electrically heated, if gas is not available, or it may be either oil fired or steam heated, if desired.

Equipment for heating ovens with oil may be obtained from Hauck & Co., Brooklyn, N. Y. A monorail system with a 1-ton, chain hoist is almost a necessity. This monorail should extend the full length of the shop and be arranged so that it passes directly over the lathe, the dipping vats, right into the oven. A switch should be arranged so that motors can be handled from trucks at the doorway, or so that trucks can back under the monorail.

One or two armature racks should be built of 4-in. by 4-in., or 4-in. by 6-in. timbers, bolted together and well braced. A table of heavy material should also be built for supporting stators, while being wound. Both table and armature racks should have casters about 3 or 4 in. in diameter; smaller casters are a source of annoyance. The workbench should be provided with drawers for hand tools and should be well lighted both for night and day work, since there will be many overtime jobs on elevators and other important equipment.

The supplies needed will vary somewhat, depending on whether the equipment to be repaired is large or medium-sized, and also on whether the larger portion is a.c. or d.c. If the town of Don Miguel does not have an electrical supply house, the stock would probably have to be larger than ordinary. The following stock of tape, will be required: 1-lb. rolls of ¾-in., friction tape; ¾-in., cotton tape in rolls about 3½ in. in diameter, for use on the taping machine and ¾-in., varnished-cambric tape in 3½-in. diameter rolls so that it may be used on the taping machine for high-voltage equipment. The thickness of the tape should be from 0.010 in. to 0.015 in.

Fishpaper is the most commonly used insulating

paper and the untreated variety is the most flexible. The moisture content is only about 7 per cent, which can be reduced by heating the machine before dipping. The thicknesses generally used are 0.010 in., 0.015 in. and 0.020 in., which may be combined to obtain almost any thickness desired. A supply of fibre sheets 18 in. by 30 in. and of $\frac{1}{8}$ in., $\frac{1}{16}$ in. and $\frac{1}{32}$ in. thickness will be needed for wedges and strips. Flexible mica, used for insulating transformers, molding mica, used for commutator cones and slip ring insulation, and commutator segment mica come in sheets approximately 18 in. by 30 in. and should be obtained in thicknesses of 0.020 in., 0.025 in., 0.030 in. and 0.035 in. Molding mica sheets 0.045 in. and 0.050 in. thick should also be obtained. An insulation cutter should be bought, as it will be found useful in cutting tin clips for bands and fastening coils before taping. It will also be found necessary in preparing insulation for closed slot stators and other equipment. Several sizes of cotton sleeving should be stocked and if d.c. or wound-rotor a.c. motors are to be repaired, various thicknesses of carbon and one or two sizes of pigtail wire will be needed for brushes.

Magnet wire will be an important item in your stock. It is made round, square and rectangular, which would make it impossible to stock every size and shape required; so the best thing to do is canvass the possible customers and ask permission to check up on their equipment. Obtain the horsepower and note whether d.c. or a.c., single- or poly-phase. Also note the temperature rating. Procure a wire gage and find the size of wire, from a stub, if the motor is of unusual design or size. The average a.c. or d.c. armature will have wire ranging from No. 9 round to No. 17 round. In small motors the wire will range from No. 20 to No. 33. Large stators and wound rotors sometimes have square, and in other cases rectangular, wires. In an emergency substitute round wire for this odd-shaped wire, but try to keep the circ. mil. area the same, using the wires in parallel. Sometimes on a.c. windings the slot span can be changed to make up for the loss of copper. Copper bars can be reinsulated.

Paint is to the armature winder what putty is to the carpenter, "a friend in need." I prefer yellow or amber baking varnish for oilproofing; when the finished machine is removed from the oven, and is still hot, I spray or brush it with black air-drying varnish. Black varnish gives a neat appearance and also makes the machine practically waterproof.

Tinned steel wire, sizes No. 16 to 21, will be required for bands on single-phase and wound rotors and d.c. armatures. Burnley's soldering paste and soldering acid will be needed, as well as half-and-half solder wire, which is sold by the pound on reels weighing from 10 lb. to 50 lb. A solution of denatured alcohol and rosin can

be used as a flux for soldering armature bands. Shellac gum is bought by the pound, or it may be purchased already prepared in one quart or larger containers. Amber shellac is best for all-around use. Glue should be bought in half-pint or pint cans, Le Page's glue is considered good.

P. F. W. will have to use his own judgment in selecting material, as he is familiar with the district in which he is located and knows whether he has any competitors, and their strength. He can also determine the amount of equipment installed in the town or district and from this determine what materials he should have on hand. GRAY H. EMERSON.

Birmingham, Ala.

Will Flexible Couplings Reduce Gear Shock on Motors?

QUESTION.—I would like to obtain the views of some of our readers on the value of a flexible coupling in preventing the shock and vibration of gears from reaching the motor armature and commutator. We have encountered some trouble from vibration and gear shock affecting commutators and I am wondering if flexible couplings between the motor and the gear drive would help me in eliminating this trouble.
Omaha, Neb. M. P.

ANSWER—Replying to M. P., question, I have used flexible couplings on all kinds of drives, including small and large centrifugal pumps operating at 1,750 r.p.m.; also on geared hoists of 100 to 300 hp. operating at 400 r.p.m. and having straight and herringbone gears, with satisfactory results. Several have been in continuous service for nine years without any repairs. I have also had good results in using cloth pinions (made up under various trade names) for absorbing the shock on motor shafts of small and large geared reciprocating pumps, deep well pumps and other heavy equipment. The character and conditions of load, with reference to speed and location of motor, would be the deciding factor in favor of the flexible coupling or silent pinion.

WILLIAM J. MILDON.

Supt. Power & Equipment,
Madeira Hill Coal Mining Co.,
Philipsburg, Pa.

Use of Non-Metallic Gears

QUESTION.—I wish that our readers would give me their experience with the so-called non-metallic gears. We have several gear drives which wear rapidly, due to irregular loading, and soon become noisy. If I should use non-metallic gears would I have to use pinions with wider faces, and also have to replace the present gears with others having wider faces? If so, approximately how much wider would the faces have to be?
Des Moines, Iowa. J. F. K.

ANSWER—Unfortunately, the information given by J. F. K. is not sufficient to make any definite recommendation as to the use of other materials and gear tooth widths. If the horsepower transmitted, the diameter and speed of the pinions, and whether they were made of cast iron or steel were known, some direct information could then be given in regard to the possibility of substituting some of the various types of non-metallic gears for the metal gears now used.

Up to the last decade, when the research departments developed a gear material from cotton sheets that were treated and compressed under enormous pressure, the chief non-metallic gear material was rawhide, a material that has served acceptably in drives ranging from small machinery to street car motors, pumps, and so on. Data on these new non-metallic gears (sold under trade names) may be obtained from their makers, but it should be remembered that an arbitrary substitution is not a guarantee of freedom from the present troubles.

These troubles go back to gear application design. It is well known that a gear may not wear well even though its individual teeth are strong enough to carry the load placed upon them. The remedy in such a case is to use wider faces. An old rule-of-thumb check on gear teeth has been to make the width of the tooth, in inches, at least 4½ times the number of horsepower transmitted divided by the pitch diameter of the gear in inches. The tendency toward high motor speeds has made it necessary to use better materials because cast-iron pinions, even though they had been designed according to this check, which was for ordinary machinery, would not stand up at the high speeds. As a result, pinions made of untreated and case-hardened steel and non-metallic compositions and materials of various kinds have been introduced to carry the increasing loads without increasing the width to undue sizes. In the street car field, and in some industrial work, hardened tool-steel pinions have given double the life of the soft steel ones so long in vogue.

J. F. K. says the pinions "become" noisy which implies that they were quiet at the start. It is evident that the load is too great and the speed too high for the width of face. At high peripheral speeds, 1,700 f.p.m. and over, unhardened metal pinions wear rapidly, due to the shock of contact and all gear formulas take this into consideration. It is at such velocities, and beyond, that the rawhide gear found favor because it cushioned the shock and was less noisy; it has been customary when using the best quality of rawhide to disregard peripheral speed altogether in designing gears.

According to the Lewis formula for gear teeth, rawhide teeth should have 1½ times the width of cast-iron teeth and 3 times the width of teeth made from 0.30

per cent carbon steel, if each is to transmit the same power.

J. F. K. would be no better off if he used non-metallic pinions unless he changed to new gears also, because the load-carrying area of the pinions is limited by the width of the gears. Also, it is very likely that the gears have worn so that they will continue to cut pinions as fast as new ones are installed. Good cut teeth roll, properly meshed, upon one another, but as soon as they wear out of shape the points in contact slide on each other and the resultant friction constantly wears on particles of metal.

J. K. F.'s troubles, however, may not be entirely due to too narrow faces. In many cases, the motors and the shafts they drive are not lined up parallel in both horizontal and vertical planes. This result in a condition which will start tooth wear the moment the switch is closed.

Where a motor is insecurely mounted or supported, or the driven shaft is loose in its bearings, misalignment and the same wearing conditions will result. When two gears do not line up the contact is at one end only, even if the gear and pinion are several inches wide and the amount of contact cannot be increased until that end has worn down. The wear, however, does not follow the theoretical shape of correct teeth, with the result that there is constant friction and noise throughout the shortened life of the gear and the pinion that meshes into it.

There is but one correct meshing position for a pinion in its gear. Owing to the difficulty of lining up motors, the best check is to use slips of paper or thin metal between the teeth before running the drive at all. These slips have to be rolled in place by turning the motor over by hand. They should "pull" the same in four positions; that is, at the top and bottom of a given tooth, at both ends.

In irregular loading J. F. K. has hit upon one of the most common troubles in the realm of transmission but withal one which is often given the least study. Irregular loading is often the cause of a noisy drive; to overcome this herringbone gears are being substituted in many cases. These gears, from the nature of their tooth angle, run quieter because backlash is better taken up than with ordinary spur gears. With intermittent loads, much of the noise is due to the rebound and does not result from contact between oncoming teeth.

The writer had a case of a motor drive on a metal planer that could not be silenced by gears, but was effectively silenced by use of a Morse chain and a compensating driven sprocket. On this installation a 6-ton table load, together with four large pulleys traveling at about 5,000 f.p.m., had to be reversed

several times a minute. We had no trouble with gear tooth wear; however, the noise was so bad that the planer had to be stopped in order to use the telephone in a booth in the office about 100 ft. away. Even though we installed new pinions and new gears, then non-metallic pinions and new bearings all around, none of them had any effect upon the noise. However, the chain drive was so quiet that a whispered conversation could be carried on alongside the machine itself.

DONALD A. HAMPSON.

Plant Superintendent,
Morgans & Wilcox Mfg. Co.,
Middletown, N. Y.

What Is the Best Type of Drive for This Installation?

QUESTION.—I should like to have the advice of readers on the following problem. We wish to operate by a 10-hp., 1,150-r.p.m. motor, a small machine shop and a small reciprocating pump, which are in different rooms, separated by an 8-in. brick wall. We wish to place the motor in the room with the pump. There are three possible drives. (1) Mount the motor on the floor or wall and use a short, overhead lineshaft with three pulleys, one for the motor belt, one for driving the pump and the other for driving the machine shop. (2) Mount the motor on the ceiling and connect it directly to a short lineshaft with two pulleys, one for the pump and one for the machine shop. (3) Mount the motor on the floor and drive the pump directly through a speed reducer. In this case I would use between the motor and the speed reducer a short piece of shaft on which would be mounted a pulley driving an overhead shaft, which in turn would be belted to the machine shop lineshaft. Will someone please tell me which of these combinations would be best from the standpoints of cost, maintenance and operating advantages? Do you know of a better type of drive than I have outlined?
Chicago, Ill. O. H. E.

ANSWER.—Referring to O. H. E.'s problem, a little more information, such as the following questions suggest, would help in deciding which arrangement is the most efficient. Is the machine shop load constant? Is the shop operated intermittently or continuously when the pump is operating? Does the pump operate continuously or intermittently, and at what speed? It the motor a.c. or d.c.? Are clutches to be used for disengaging units for no-load starting of the drive?

Arrangement No. 1 is the cheapest, most practical, and represents the most common practice. Clutches may be used on each side of the main drive pulley on the line or jackshaft to throw off the machine shop load as required, or in case of accident. The pump can similarly be thrown in or out of service as occasion demands, and the starting of the motor facilitated by disengaging the clutch.

Drive No. 2 has the disadvantage that the jackshaft speed would be too high, unless a special ball or roller bearing construction were used. Also aligning

the motor with a shaft would require four bearings in line, which is objectionable unless a flexible coupling were used between the motor and jackshaft. Altogether, this arrangement is not very flexible and practical, considering individual operation and starting.

Drive No. 3 is the most expensive, as several flexible couplings would be required if the speed reducer were mounted between the motor and pump. This arrangement is not very flexible, and like arrangement No. 2 would require a higher grade of maintenance service.

E. H. LAABS.

Engineering Dept.,
Cutler-Hammer Mfg. Co.,
Milwaukee, Wis.

Lining Up Sprockets for Chain Drives

QUESTION.—Can some reader tell me the best and simplest method of lining up sprockets, or shafts, for chain drives? We frequently change machines around and install new drives or replace old ones, and I should like to be sure that we are lining these up properly.

Decatur, Ill. J. L. B.

ANSWER—With reference to J. L. B.'s question, I presume that he has reference to chain belts of the type manufactured by the Link-Belt Company, the Morse Chain Co. and the American High Speed Chain Co. I have handled such drives for the past six years and use the following methods, which have always proven entirely satisfactory:

Referring to the sketch, take two pieces of $\frac{1}{8}$-in. galvanized pipe of the proper length to suit the requirements, which depend entirely upon the centers of the shafts. About 42 in. to 48 in. is the maximum that I have had to deal with, with a $2\frac{1}{2}$-to-1 or 3-to-1 ratio. Drill two holes through the end of one pipe, the first hole being about $\frac{1}{4}$ in. from the end; the other hole should be about 1 in. further back. I use a No. 21 drill. Tap out the holes for 10/24 or 10/32 machine screws. Drill both ends of the first piece of pipe in this manner:

The second piece of pipe requires no holes, but a round piece of iron stock should be driven tightly in one end for fitting into the second section. Drill a small hole through the pipe and rod and put in a small iron rivet, peening it over on the under side.

Round out the opposite end of this piece sufficiently to fit over the sprocket tooth. Then fit a Starrett inside micrometer into the other end of the first piece of pipe. At (A) in the sketch is shown a complete assembly of the gage ready for use. This is really an adjustable pin gage.

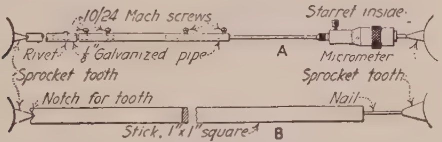
Place the two sprockets face to face in approxi-

mately the position in which they are to run; then center them by squaring the sides with a steel straightedge or its equivalent. Gage in between the teeth, as shown in the sketch, until the outside edges of the two teeth selected are within 0.003 in. of being parallel. If the centers are then correct, the sprockets are lined up about as closely as it is possible to get them for all practical purposes. Sprockets should be carefully examined before placing on the shaft to detect blowholes and eliminate any high spots that might exist. When machining, blowholes in the inside of the shaft hole cause the tool to jump and the result is high spots. If this condition is not remedied a "wobble" will result.

In case an inside micrometer cannot be obtained, a piece of yellow pine 1 in. square can be used. Cut the timber to the proper length, notch it on one end and drive a small nail into the other, filing off the head to a round point. Adjustment can be made by driving in or withdrawing the nail with a pair of pliers. If this outfit is carefully used the results obtained will be about as good as with the micrometer.

A chain belt should never be too loose; the sag in operation should never be over 1 in. or $1\frac{1}{2}$ in. on the slack side; otherwise in case of a reversible drive or dynamic braking a slap will result.

For roller sprockets a good straightedge or fine chalk line applied to the sides of the sprockets to bring them center to center and in alignment, should be sufficient.



Method of aligning chain drive sprockets, A, by means of improvised pin gage and, B, by a wooden stick.

I have used the above tools for a good many years and have yet to hear a complaint about a drive so lined up. The tools employed can be obtained in anly good industrial plant machine shop. Any mechanic can make for himself the two pieces of pipe used for an extension, and when once made they are always ready for use. The joint in the pipes is for dismantling so that they can be placed in the tool case; otherwise a joint is not necessary unless the shaft centers are rather short.

P. S. PENDER.

General Engineer,
Metropolitan Engineering Co.,
Granite City, Ill.

Selecting Belts for Oily Work

QUESTION.—We have had considerable trouble with the drives in the screw machine department of our plant due to the belts getting soaked with oil. We have been using leather belts. I would like to know whether there is any treatment I can give these belts to make them oilproof or if there is any belt which is not affected by the oil. Also, how do other men with a similar problem remove the oil from the used belts and put them in condition for service again?
Chicago, Ill. G. F. H.

ANSWER—There is to my knowledge no belt made which will stand up and give anything like efficient and continued service under the oily conditions too often found on screw machine work. Naturally, the more the belts can be protected from the oil spray the better the service that can be secured. As it is impossible to keep oil entirely *off* from these belts, the only thing to do is to keep it *out* of the belts, because leather belts are without question the best for this service. I would suggest that you thoroughly fill the belt with a belt dressing of heavy density. The belt cannot thereafter absorb much oil because it will already have absorbed its fill of a preservative material heavier than the oil and which the oil will not displace from the fibers of the belt. By wiping the surface oil off the belt day by day and applying a little belt dressing, good results can be secured.

To remove the oil with which the belt is saturated, the belt can be immersed in gasoline for 48 hr. and then hung up to dry, or in place of the gasoline a non-flammable belt cleaner, such as made by belt dressing manufacturers, can be used. WM. D. YOUNG.
Cling Surface Company,
Buffalo, N. Y.

Reclaiming Leather Belting

QUESTION.—I should like to know if any readers have made an investigation to determine how much belting must be in use before it will pay a plant to undertake belt reclamation work. I should also like to know the amount and kind of equipment required to do such work and about what savings we could expect to make. I shall appreciate any suggestions or information you can give me.
Cleveland, Ohio. E. E. L.

ANSWER—Replying to E. E. L.'s question on reclaiming leather belting, we would say that if we understand your question what you want to know is how large a plant you must have or how much belting in use before it pays to set up an equipment for reclaiming, that is, degreasing, lapping, re-gluing, etc. The answer to this will pretty obviously depend upon the nature of the drives; in other words, upon how quickly belts are deteriorated due to the nature of service to which they are subjected.

Where there is a great deal of oil or dirt around, it probably would pay to reclaim belts in a plant where there was less belting in use than in a larger and cleaner plant where the conditions were more ideal. A gasoline tank of sufficient size to hold the belts in loose rolls would be required, with proper safeguards for fire hazard, and preferably the work should be done out of doors or in a shed distant from other buildings of importance. There should be a dry, airy shed out of the buildings where the belts can be allowed to dry, that is, the gasoline to evaporate, and, of course, the size of this will depend entirely upon the amount of work done. In the summer time it can ordinarily be done outdoors; possibly in a garage or some such place which is open and not closed up tightly.

After the leather is degreased, it will have to be re-lapped. A good set of belt tools, including a small lapping machine, such as the Prims Machine made by J. C. Prims, Hornell, N. Y., should be installed. A man who understands the cutting of laps, gluing, cement, etc., will be required, and then a small treating tank, in which the belts could be treated in a proper belt preserver.

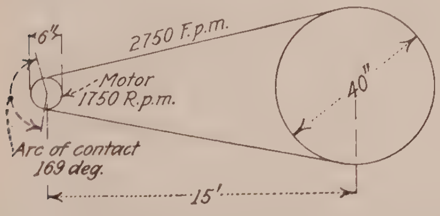
J. EDGAR RHODES.

J. E. Rhodes & Sons,
Philadelphia, Pa.

What Size of Belt Is Required for This Drive?

QUESTION.—A 15-hp., 1,750 r.p.m. motors is used to drive a punch press. The pulley on the motor is 6 in. in diameter and the driven pulley is 40 in. in diameter, the distance between centers of the motor and press pulleys being 15 ft. I wish readers would give me some information regarding the adaptability of leather belts to this drive. Specifically, what width of leather should be used to give the best results? Should this belt be single or double-ply? Would you advise the use of some other type of belt and if so, what kind and why?

Rockford, Ill. R. W. A.



The accompanying drawing shows the transmission layout for R.W.A.'s punch press problem, in which he asks about the drive leading from the motor. The exact location of the motor, whether on floor, ceiling or a wall bracket, doet not affect the case. [Note: Where the center line of the drive is at an angle of over 40 deg. from the horizontal allowance must be made in computing the power transmitted, particularly when the small pulley is located below.]

ANSWER—In reply to the question of R. W. A. I offer the following solution: Correct belt application depends upon several factors; namely, speed, thickness, width, the arc of contact between the smaller pulley and the belt, the material of which the belt is made, and the kind of pulleys employed. The speed of a belt for ordinary purposes should range from 3,000 to 5,000 f.p.m. The operating speed in this case is determined by the formula: $(3.1416 \times d \times s) \div 12$, where d = diameter of motor pulley, and s = speed in r.p.m. of motor pulley.

For rugged service with 15-ft. pulley centers a double belt is preferable to a single belt. The width must be great enough to stand the pull of the load and be narrower than the pulley face. For pulleys of the above-mentioned dimensions the arc of contact is ample to minimize slipping. Leather should prove adaptable for a punch press drive and will be the material considered in these calculations.

A simple formula that is usable for most belt problems is as follows: $W = (33{,}000 \times \text{hp.}) \div (P \times V)$, where hp. = horsepower; V = belt velocity; P = effective pull per inch of width. For single belts, use P as 35 lb. per inch in width, while for double belts 70 lb. may be allowed. $V = (\pi \times d \times s) \div 12$ or $(3.1416 \times 6 \times 1{,}750) \div 12 = 2{,}748.9$ or, for practical calculations, 2,750 f.p.m. Substituting this value in the formula for width we have: $W = (33{,}000 \times 15) \div (70 \times 2{,}750) = 2.57$ in. Instead of using a $2\frac{1}{2}$-in. double belt I would use the next size larger which would be a 3-in. double belt. JOHN B. RAKOSKE.

Schenectady, N. Y.

Comparative Advantages of Two-Point and Four-Point Adjustable Hangers

QUESTION.—I am planning on installing an additional section of lineshaft and would like to get the opinions of other readers about whether to use two-point or four-point adjustable hangers. What are the advantages of each from the installation, operation, and maintenance standpoints? Would these advantages be worth the difference in cost? This will be a $1\frac{15}{16}$-in. shaft, 50 ft. long. The present installations are all two-point adjustable hangers. Will other readers tell me what they would use and why?

Indianapolis, Ind. B. K. W.

ANSWER—Regarding B. K. W.'s question, the writer would say that in his experience the four-point hanger is practically always preferable to the two-point hanger for line- and countershafting. Nearly all hangers have slots or elongated holes in their feet which allow them to be adjusted sidewise or perpendicularly to the line of the shaft. Setscrews are also provided in the hanger frames for vertical adjustment of the boxes in which the shaft revolves.

The four-point hanger has setscrews in each side of the frame in addition to the top and bottom setscrews; in this way adjustment of the box within the frame is provided in both directions. With the two-point hanger, where the setscrews provide vertical adjustment only of the box, the lateral adjustment is secured by loosening the nuts on the bolts in the hanger feet and shifting the entire frame in the required direction. Obviously it is much less troublesome to secure the lateral adjustment by means of the setscrews in the frame. When the nuts on the bolts in the feet of the frame are removed, there is for the moment no support for the shaft at that point and it has to be supported while the entire hanger frame is shifted.

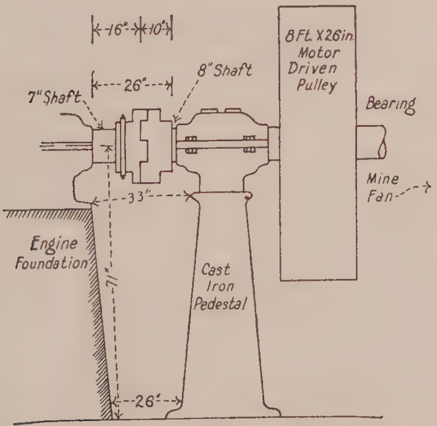
It might interest B. K. W. to know that standard steel sections can now be secured for supporting shaft hangers. These sections, used in the same way that wooden stringers have been used, allow any required amount of lateral adjustment for the hangers. In other words, the hanger can be slid along the steel section by means of a sliding bolt seat. These sections are clipped into place in wood, steel or concrete buildings and no holes have to be provided for the feet of the hangers.

P. L. Pryibil.

Vice-President,
Midwest Steel & Supply Co., Inc.,
New York, N. Y.

What Kind of Clutch Should Be Used Here?

QUESTION.—I should like to get your opinion on a clutch to be used for driving a mine fan. The sketch shows what we have at present, but it is not very

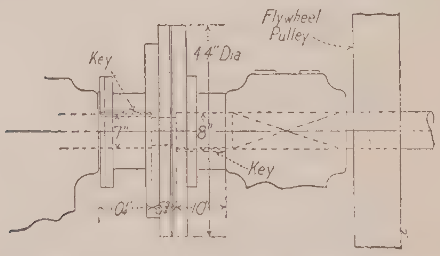


satisfactory, due to the flywheel effect of fan and pulley, which causes excessive wear on the square-jaw clutch and results in back-lash at every stroke of the engine. The engine is rated at 250 hp. at 17[illegible]

r.p.m. and operates at full capacity, in one direction only. The clutch is used so that the engine may be thrown out part of the time and the fan driven by a 250-hp. motor belted to the pulley. What type of clutch could I get that would fit into these dimensions and be able to carry the load?
Bicknell, Ind. H. S. B.

ANSWER—With reference to H. S. B.'s question, the accompanying sketch shows an electro-magnetic clutch in place of the mechanical, manually operated jaw clutch. Jaw clutches have not proven satisfactory when operated direct connected with steam engines, due to the pulsating effect. A magnetic clutch can be used to fit into the dimensions shown. A clutch of this type permits a certain amount of variation in angular velocity which is taken up on the brake lining. The clutch can be operated, or engaged, when connected to the steam engine and disengaged when the fan is belt-connected to the motor, on 115 or 230 volts direct current by means of a push button, to give remote control. This is a decided advantage over any form of mechanical type of clutch as it eliminates the manual operation of engaging, which usually requires barring the flywheel to get the jaws in position.

The sketch shows a 44-in. diameter magnetic clutch the use of which is based on condition that the clutch be engaged before the engine is put in operation, and depends on the characteristics of the fan and the WR^2



Installation of 44-in. Cutler-Hammer magnetic clutch, rated 250 hp., at 175 r.p.m.

value of the flywheel pulley. If it is desired to engage the clutch after the engine is in motion, a larger clutch will be required and the size will depend on the load to be accelerated.

Further information can be obtained by writing to the Cutler-Hammer Mfg. Company, Milwaukee, Wis.

E. H. LAABS.

Engineer, Printing Equipment Dept.,
The Cutler-Hammer Mfg. Co.,
Milwaukee, Wis.

Connecting Lineshaft Directly to Motor

QUESTION.—We wish to connect a lineshaft approximately 100 ft. long directly to a 50-hp., 870-r.p.m. motor. The lineshaft can if necessary be supported from the ceiling, but we should prefer to mount it on top or at the side of heavy wooden or concrete posts. This department is on the ground floor and there is no basement underneath the building. I should like to know (1) if it is practicable to drive a lineshaft at this speed. (2) Would it be better to support the lineshaft on the top, or at the sides of the posts? (3) Is there likely to be an excessive vibration? If so, how can it be overcome? (4) What kind of bearings should we use? Your advice will be greatly appreciated.

St. Louis, Mo. B. G. S.

ANSWER—Referring to B. G. S.'s questions, (1) operating a lineshaft 100 ft. long at 870 r.p.m. is not practicable. Without knowing the service conditions, that is, the kind and type of machines that are to be driven from the lineshaft, it is difficult to say what the r.p.m. should be. For machine shop service 200 to 250 r.p.m. is desired; for woodworking shops 240 to 250 r.p.m. is used and for envelope machines, small printing machines and the like about 200 r.p.m. is being used.

(2) Supporting the shaft on top of the posts would be more desirable, using either the inverted shaft hanger or pedestal-type pillow blocks. Concrete posts with their foundations resting on good, hard sub-soil and independent of the building foundations, are practicable for such service. Mounting the bearings on the side of the posts is feasible, but more expensive and in some cases requires more maintenance.

(3) Vibration depends on the size of the shaft, its speed, distance between hangers, the number of driving pulleys between hangers, and the nature of the load or kind of machines driven. The spacing of hangers may be from 10 to 15 ft., and the load should be equally distributed near the hangers, with the light machines placed in the middle of the hangers. The motor should be placed in about the middle of the shaft so as to divide the torsion in the shaft. The heaviest load should be pulled near the motor, and the lighter load at the ends of the shaft. If certain machines are to be idle at times, it would be advisable to group them and divide the lineshaft into sections, with mechanical clutches or magnetic clutches to disengage the sections not in use. This arrangement has the advantage that should a breakdown or accident occur on some machine, that section can quickly be thrown out of service without holding up production on all machines.

A large diameter shaft, close spacing of hangers, and a lower speed than is stated in the question, will keep the vibration within safe limits.

(4) A roller bearing made in two halves or sections

would be practicable and economical for this installation and would lower the cost of maintenance.

The motor could be arranged to drive to the lineshaft by means of a silent chain drive which is economical, silent, positive and low in maintenance cost. Placing the motor on a platform or foundation elevated from the floor so as to have about 30- to 40-in. shaft centers is practicable. For this installation a $1\frac{1}{4}$-in. pitch by 5-in. wide, continuous-duty chain would be required. This would cost approximately $170. E. H. LAABS.

Engineering Dept.,
The Cutler-Hammer Mfg. Co.,
Milwaukee, Wis.

Checking Alignment of Lineshafting

QUESTION.—We have two long, and several shorter lengths of lineshafting which I know is somewhat out of line, probably due to settling of the building. I shall appreciate it very much if someone will give me a simple methods of lining up these shafts accurately in the hangers, so as to reduce friction in the hanger bearings.
Milwaukee, Wis. S. V. B.

ANSWER—In reply to S. V. B. when aligning shafting without any special equipment I would suggest that he first run a line parallel to the shaft at the same dis-

LOCATION- ____________

DATE - ____________

Hanger No.	High	Level	Low	Right	Line	Left
1		X			X	
2	3/16"				X	
3	1/8"					1/4"
4			1/8"			1/8"
5			3/16"		X	
6			1/4"	1/8"		
7			1/8"	3/16"		
8		X			X	
9		X				1/8"
10		X			X	

This chart is used to record the data taken when checking the alignment of shafting.

tance from the floor as the center of the shaft, and as near the shaft as it can be conveniently put, and yet

clear all hangers and pulleys. Have this line exactly the same distance from the center of the shaft at each end.

Then, using an ordinary carpenter's level and a straight-edge equal in length to the distance between the hangers, start at one end of the shaft and by means of the straight-edge and level find out how much, if any, the second hanger is higher or lower than the first. Also measure over to the line and determine if this hanger is out to the right or left, and if so how much.

Now using a chart prepared as shown in the illustration, proceed the entire length of the line, and obtain the position of the shaft at each hanger.

You can then examine each hanger and decide if it is practicable to put it where the chart calls for. In some cases it may be easier to raise or lower the entire shaft, or to move it sideways slightly. If you find the shafting so much out of level that it would be too expensive to make it level, it may be "graded in."

To do this divide the amount which one end must be lower than the other, by the number of spaces between the hangers, which will give the amount that each hanger must be higher or lower (depending on whether you start at the low end or the high one) than the one before it.

After the shaft has been put in the proper position, according to the chart, go over it once more as a check upon the accuracy of the work.

When the shafting in a plant is periodically aligned, file the charts away for future reference; then by comparing a number of charts obtained from any one length of shaft it can be determined if any of the hangers have been out of line in the same direction each time, and if so, the trouble can be located and remedied. DONALD MAXFIELD.

Head Machinist,
Old Town Woolen Co.,
Guildford, Me.

Where Does a Lineshaft Usually Break?

QUESTION.—Recently a $4\frac{3}{16}$-in. shaft broke underneath the hub of a 36-in. pulley sheave carrying eight $1\frac{1}{4}$-in. ropes. Several millwrights have told me that a lineshaft always breaks in the hub of the pulley, but none of them could tell me why. I should like to know if other readers have had a similar experience and if they can give any explanation of why the shaft breaks in this location. I am anxious to avoid a repetition of this trouble, if possible.
Chicago, Ill. R. C. M.

ANSWER—Referring to R. C. M.'s inquiry, an explanation in simple terms would be that a shaft breaks in the loaded pulley, first, because the pull of the belt or ropes produces the greatest bending there, just as a man

breaks a stick over his knee; second, because at that point there is usually a keyway to weaken the shaft and provide a sharp corner from which to start a crack; and, third, because, with the turning of the shaft there is with every revolution a back-and-forth bending action which eventually, if the pull is at all heavy, causes crystallization, or fatigue of the metal, which may eventually result in a break.

One might think that the pulley hub has sufficient reinforcing effect to stiffen the shaft and cause the break to come at one side, and occasionally it does. However, in practically all cases where split pulleys are used there is given enough in the bolts to allow the shaft to deflect to some extent inside the pulley hub, and most solid pulley hubs have sufficient clearance for slipping on the pulley while the metal in the hub is light enough and compressible enough in the bore to permit considerable bending.

We have had several breakages of this sort, but as the belts were not unduly tight and the shafts were of ample size for the horsepower carried at the speed we were inclined to suspect that the material of the shafts was not adapted to cold rolling and that a certain amount of crystallization or an incipient flaw existed when the shaft was installed and gradually developed in operation. On replacing the defective shafting with shafting from another source, no such trouble has recurred. H. D. FISHER.

Plant Engineer,
New Haven Pulp & Board Co.,
New Haven, Conn.

Removing Flange Couplings from Lineshafting

QUESTION.—In the rearrangement of a group of machines, it was necessary to remove some solid pulleys from a lineshaft and replace them with others. This necessitated removing and replacing the flange couplings. We were not able to replace them so that they would run true and had to turn them down. I would like to know how other readers remove and replace flange couplings on lineshafts.
North Chicago, Ill. G. F. H.

ANSWER—Answering the question asked by G. F. H., possibly the trouble which appears to be in the coupling is really in the shaft; it may be out of line or level.

If the flanges had been prick-punched before removal they would likely go together properly; in fact, they may have been so marked on their edges, but the marks were not found. I would recommend a good cleaning of the coupling and a close search for file cuts or punch marks before any turning down is done.

Then again, if it is impossible to line up the two parts of a coupling exactly they could be separated anywhere from ½ in. to 1 in., leather disks inserted

between them and then bolted tightly together, if the load is not too heavy. A coupling altered in this way will be more or less flexible. If the shaft is traveling fast, say over 150 r.p.m., it would be safer to place a hanger on each side of the coupling so that in case the leather should tear apart the shaft ends, being very short, could not bend at right angles and whip around, due to centrifugal force. H. S. RICH.
New Britain, Conn.

Putting Tires on Wheels of Bandsaws

QUESTION.—Will someone be kind enough to tell me what is the best method of putting tires on the wheels of bandsaws? I shall appreciate this information very much.
Chicago, Ill. J. W. C.

ANSWER—J. W. C. asked recently for the best method of putting tires on wheels of bandsaws. I retired two machines recently and he may be interested in learning how I did it. First, I removed the old tires from the wheels and sandpapered the latter until all of the old rubber and cement was removed. Then I applied a liberal coat of cement made for this purpose and stretched the new tires on over the wheels. I allowed the cement to dry over night before using the bandsaw. If a special, prepared cement is not furnished with new tires, a coat of heavy varnish may be used instead of this, with very satisfactory results. E. L. WAY.
Marietta, Ohio.

Storing Spare Motors

QUESTION.—I should like very much to have some of the readers describe the methods which they have devised for storing motors in such manner as to require the least possible floor space. We have over 200 spare motors ranging in size from ½ hp. to 85 hp. A crane is available and we can pile as high as twenty feet, but floor space is limited and I must use it effectively.
Media, Pa. A. S. H.

ANSWER—A. S. H. asks how motors can be stored so as to utilize floor space most effectively. Many motors of various sizes can not be stored as compactly as one would wish, but floor space can be saved by arranging them in pyramid fashion; that is, in separate pyramids.

I would suggest that he arrange four motors in a square; place short planks across them both ways and place thereon three or four motors of a smaller size. Cover these with planks and place one or two small motors on top.

He can then arrange other pyramids in the same way, economizing on floor space. Thus, for every four motors on the floor there are four or five more above. This scheme permits a crane to take down any pyramid

to reach any certain motor. Of course, it would pay to catalog them all and identify them by letters or numbers while in storage. H. S. RICH.
New Britain, Conn.

Ramp for Industrial Truck

QUESTION.—The basement floor of one of our buildings is 4 ft. below the grade level. We are planning on installing an electric storage battery truck for handling heavy material out of this basement and from the yard up to the first floor. What grade should be given to the incline or ramp? Would it be advisable to roughen or ridge the surface of the concrete to give the truck better footing? Part of the ramp will be outside, and exposed to the weather.
Peoria, Ill. S. L. G.

ANSWER—In reply to S. L. G.'s inquiry, he will find that the longer and more gradual he can make the ramp the easier it will be on the battery and the truck. Standard makes of trucks can be equipped with batteries large enough to handle any reasonable load on any reasonable grade. My experience has been that even where a truck is equipped with a battery somewhat larger than standard rating, a grade of 1 in 8 is about the operating limit. The truck labors on this grade with its rated load unless the battery is fresh from charging.

I do not know what figure truck manufacturers use in estimating tractive effort on level floors, but after taking into consideration the heavy going due to unavoidable irregularities a value of 20 per cent of the load, which is often used in similar work, would probably be a fair upper value. Thus a grade of 12.5 per cent on top of the regular tractive effort would increase the effort required of the motor 62.5 per cent above that for hauling on the level. I would suggest that S. L. G. make his ramp 50 ft. long, if possible, which would give a grade of 1 in 12½ or 8 per cent, as it will be much easier on the truck batteries.

For the usual rubber-tired truck wheels, a plain concrete surface, finished with a wooden float but not troweled, will give ample tractive contact, even if wet, and is much better than any form of ridges or grooves, which only bump and impede the truck. It is a good idea on a runway such as this to use an integral floor hardener, such as some of the powdered-iron preparations, as they greatly reduce the wear of the surface.

In building a ramp the grade should not start and finish abruptly, but should gradually curve from the level floor to the full slope or incline of the ramp.

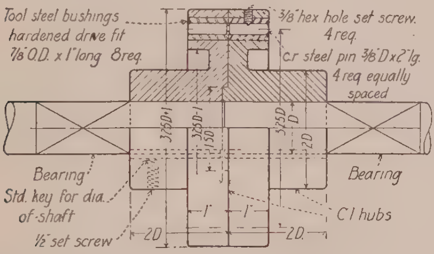
This transition at the top and bottom may well be 6 to 8 ft. This is especially important if the grade is steep, because where the transition is short and the truck under-clearance small it may rub or become

stranded when going over the top. Also the truck would tend to bump at the bottom of a sharp transition. Steering rods are usually the lowest part under the frame and should be inspected occasionally to see whether they are scraping as otherwise they may break and cause a bad wreck. H. D. FISHER.

Plant Engineer,
New Haven Pulp & Board Co.,
New Haven, Conn.

Breakage of Gears

QUESTION.—On each battery of furnaces in our refinery there is a 7½-hp., 1,800-r.p.m., motor driving a device that clears the coke from the furnace. The motor is connected by a roller chain to a shaft driving a pinion meshing with a large double gear that drives the device. This device is subjected to very unusual loads at times, especially when it is about time for the furnace to be rebuilt. These loads are so heavy and come on so suddenly that the teeth are often broken off the bevel gear, which is made of cast iron. As it is rather expensive to replace these gears, I am wondering if our readers can suggest some device that I could put on this drive to disconnect it when the load becomes too great. . Would a coupling having shear pins do the trick? How could I make such a coupling?
Tulsa, Okla. L. A. N.



The dimensions of this shearing-pin hub are given in terms of the diameter of the shaft on which it will be mounted.

ANSWER—Answering L. A. N., if the suddenly applied heavy loads do not stall the motor, it would appear that the gears are not of the proper design. Cast-iron gears repeatedly subjected to sudden, heavy loads will crystallize with the result that breakage occurs at normal or even light loads. I suggest making the bevel gears of steel castings.

A shearing-pin hub can be used to advantage in places where the machine elements are subjected to severe heavy loads.

In the absence of data regarding the speeds of the shafts, gear and chain ratios, diameter of shafts and so on, it is difficult to design the proper shearing pin device. However, the accompanying sketch gives the proportions in terms of the diameter of the shaft on which it is to be mounted. The tool steel bushings are not essential as far as the functioning of the device

is concerned, but are of value when removing the sheared pins, as they protect the hole from being torn or wedged. The shearing pins are grooved in the middle to a reduced area depending upon the maximum torque required to operate the shearing device.

Since there is not sufficient information given to calculate the torque at the point where the shearing-hub device could be located the size of the groove can be obtained by trial or actual experience. The shearing-pin hub should be supported by a pillow block bearing at each side.

E. H. Laabs.

Engineering Dept.,
Cutler-Hammer Mfg. Co.,
Milwaukee, Wis.

Drilling Holes Through Plate Glass

QUESTION.—I have to drill some holes in plate glass $\frac{1}{4}$ in. thick and wish some of our readers would tell me the best way of doing this. I have tried various methods but without much success and shall appreciate your suggestions.

Little Rock, Ark. M. J. J.

ANSWER—Replying to M. J. J., I have found the following method to be very useful indeed.

A tool for this purpose is made from a mild steel rod of suitable length, with an outside diameter approximately 0.012 in. smaller than the actual size of the hole required. The cutting end is hollowed out with a drill, leaving a wall thickness of $\frac{1}{16}$ in. The other end of the rod is held in a hand or breast drill.

A flat surface is required, such as a drawing table or desk table padded with newspapers. A piece of paper the size of the glass is marked out for the holes and the glass is laid over the paper.

A wooden block with a hole the size of the tool is placed on top of the glass and a weight, preferably one with a hole in it, is put on the wood to keep it from shifting out of place. Carborundum and turpentine are poured on the glass through the hole in the wood, and when the tool is placed in the hand drill and rotated on this abrasive, it will bore a clean hole in approximately 20 min.

If it is desired to have a smooth edge on both sides of the glass, just reverse the sides when the hole is bored halfway.

If the piece of paper with the locations of the holes is the exact size of the glass, it will help to locate them accurately when the glass is reversed. Carborundum and turpentine should be added from time to time as the glass is worn away. After the hole is started and is about $\frac{1}{32}$ in. deep, the wood may be removed, which will make it easier to feed the tool with carborundum and turpentine.

If the glass is small and a drill press is available

similar results may be obtained by running the tool at slow speed and feeding it lightly, but often, with carborundum and turpentine. J. C. Bray.
Montreal, Que., Can.

Treating Windows to Prevent Glare

QUESTION.—I would like to obtain the experience of other readers in treating windows to prevent glare from the sun, particularly on western exposures during the late afternoon. At times this is almost unbearable in parts of our shop. What treatments, if any, have other readers found satisfactory; or would it be better to use shades and, if so, what kind?
Des Moines, Iowa. D. J. C.

ANSWER—With reference to the question asked by D. J. C., it will not be necessary for him to use shades to eliminate the glare from the sun.

Proper treatment with a window coating will in most instances entirely eliminate the glare. Ordinary whiting or white wash is sometimes used, but if a study were made of the results obtained, this type of coating would not be considered desirable.

Mr. J. J. McLaughlin of the Illuminating Bureau of the Westinghouse Lamp Co., states that white surfaces reflect 82 per cent of the light, green 70 per cent, yellow 67 per cent, red 20 per cent and blue 15 per cent. From these figures it is evident that blue would be the most desirable color for a coating.

The material should be one that is easily applied, will not rub off under ordinary conditions and yet can be easily removed if necessary. A product which meets these requirements is being sold on the market today.
A. J. Lodder.

Park Chemical Co.,
Cincinncati, Ohio.

Cleaning Skylights and Windows

QUESTION.—In our plant we have a serious problem in connection with the cleaning of skylights, transoms in monitor roofs and above the first floor, large windows with steel sash. I wish some readers would tell me what solutions they use for such cleaning, and describe any easily-constructed scaffolding or other method which they use to get to this large area of glass. This has been a very expensive and unsatisfactory procedure with us so far and I would like to know what others do.
Indianapolis, Ind. J. F. H.

ANSWER—Replying to the question asked by J. F. H., we have had experience with all kinds of acids and solutions, but the best thing that I have come across is "Skybryte," which is a solution manufactured by the Skybryte Co., Cleveland, Ohio.

I do not know the exact ingredients, but I do know that it does not injure paint or metal work.

I would suggest that J. F. H. have this manufacturer send a representative, who will not only give him information in regard to the solution, but will also give

him practical information regarding the scaffolding, which he also requests. J. E. KALIS.

Cleveland, Ohio.

* * * *

ANSWER—Answering J. F. H.'s query regarding the cleaning of windows set in steel sash and located above the first floor, the difficulty of reaching them may be overcome by installing a monorail track at the coping of the building and suspending from this a car designed for the purpose. At first thought this may seem to be a round-about way to perform this job, but at several power plants where the writer has seen this system used, its first cost has been soon offset by the savings made. The car is so arranged that it can be either raised or lowered by hand power or by a motor drive, and a similar arrangement is used for propelling it around the building. B. C. SCHLEGEL.

Master Mechanic,
The Mechanical Rubber Co.,
Cleveland, Ohio.

Repairing Wooden Floors

QUESTION.—We have found that the wooden floors in the trucking aisles and particularly at corners where trucks are turned, wear more rapidly than the remainder of the floor. I would like to know the experience of some of the other readers of Industrial Engineer in making repairs for these sections of the floors. Also, we would like to know whether our readers favor flooring laid parallel to the line of trucking, crossways, or on a diagonal.

Monmouth, Ill. J. H.

ANSWER—In answer to J. H.'s question, wooden floors laid lengthwise to the line of travel are renewed more easily and cheaply than when laid either crosswise or diagonally, because in the former case every one of the boards will have been worn its full length; in the other two cases they are still good at the ends, and if they are to be salvaged, require more time for renewal.

Often a floor may be good enough outside of the trucking runway, and needs to be renewed only where it is very badly worn; the lengthwise arrangement makes it easier to do this.

Hard, thick maple flooring is the best and most economical in the end; of course, the length of time it will last depends upon the traffic. Rubber tires on all heavy trucks, such as electric tractors, etc., save wear on the flooring and the smooth surface saves the tires; together these make a neat and practical combination.

H. S. RICH.

New Britain, Conn.

Marking Rubber Gloves

QUESTION.—I would appreciate receiving any information concerning satisfactory methods of marking linemen's rubber gloves which are periodically subjected to electrical tests, as I wish to mark on the gloves the date of the last test. These gloves are used con-

stantly for both inside and outside construction work. Any help that readers can give me will be greatly appreciated.
Lowell, Mass. J. H. J.

ANSWER—Answering J. H. J., I would say that in marking rubber gloves that are subjected to periodic tests, one is confronted with more or less of a problem. About the easiest way to mark each glove is to turn back the cuff and enter the date of test on the inside of the glove in ink, but this record is likely to be destroyed if the gloves are in constant use. A better method is to assign each man a pair of gloves, to be kept in a light-weight canvas bag. This bag can be numbered by painting the desired numeral on it. A record is then made of the bag numbers and at stated intervals the gloves are all tested, and the condition of gloves, bag, and leather protectors for the gloves entered on a chart for that purpose, and filed for permanent record. PHIL D. COMER.
San Bernardino, Cal.

Alarm System to Indicate Hot Bearing

QUESTION.—We have had considerable difficulty on some heavy pressure rolls due to bearings getting too hot before they were discovered. I have heard that it is possible to use an alarm system of some sort for indicating when bearings get beyond a certain temperature. Can any readers tell me how a device of this sort may be made and installed?
Gary, Ind. L. M. C.

ANSWER—Answering L. M. C.'s question, I would suggest that a thermo-couple be placed in the bearing shell, or attached to it in such a way that it will be directly affected by the heat. The leads should be connected to a pyrometer, an instrument which registers the temperature in degrees. On the scale of the instrument place a small contact at the point where it is desired to have the alarm sound. The needle or pointer will be the other contact. To these contacts connect a battery circuit with a small relay in series. The relay must have a movable contact and should be connected to a 110-volt lighting circuit, with a bell, horn, lamp or other signaling device in series. A small electromagnet with an armature bearing a contact may be used in place of the relay.

As the bearing heats up during operation the indicator of the pyrometer will move across the scale so that the temperature can be read in degrees at any time. When the maximum allowable temperature is reached the contacts on the scale will close, which will cause the relay to be energized and close the alarm circuit. The leads from the thermo-couple to the instrument should be as short as possible in order to keep the resistance down. PAUL E. THOMAS.
Seattle, Wash.

Trouble With Solder

QUESTION.—We are having considerable trouble in making soldered joints hold on rectangular wire in coils that are subjected to rather high temperature, such as might be the case in series field coils and brake series coils. We have tried an 80 lead—20 tin solder, but it melts due to the excessive heat. Can our readers suggest any methods that will enable us to join these wires together in a manner that will stand rather high temperature? I shall be very much indebted to any reader who can give me some help in this matter.
Norton, Va. W. H.

ANSWER—In regard to W. H.'s question, I believe he will find brazing the best process for connecting two ends of wires together for use where there is excessive heat. Take a piece of hard carbon and file a slot large enough to take the size of wire to be used. Clean the wire thoroughly and space the ends ¼ in. apart in the carbon slot. A welding torch with the smallest tip available is best for welding so small a joint, but a gasoline blow torch can be used if it throws a large flame.

When the joint is at a good red heat apply Brazo flux which is manufactured by the Oxweld Acetylene Co., Long Island City, N. Y. After applying this flux very freely, add enough spelter, a brass alloy, to fill the ¼-in. gap between the wires and hold the torch flame on this joint until the spelter runs freely. Allow the soldered ends to cool slowly in the air but do not apply water as it will make the brazed joint brittle.

Where a joint of this type is used in a coil try and cut the wire so it will not make a bend at the joint. After the joint has cooled file it down to the size of the wire. From my experience a splice of this kind has always made an ideal connection. C. L. PHELPS.
Electrical Dept.
Illinois Central Railroad Co.,
Centralia, Ill.

Static on Belt-Driven Machines

QUESTION.—We have about 200 sewing machines all of which are belt driven. The girls who run these machines complain that they frequently get shocks from them. I believe that this is due to static from the leather belts which drive the sewing machines. I shall appreciate it very much if some reader can tell me how to prevent this trouble. I have grounded the sewing machines but the trouble still continues. To what should I ground the machines so as to obtain the best results? How should the ground be made? I might say that the sewing machines are placed on wood floors in a room that is quite dry and warm. Would the use of rubber belts correct the trouble I am encountering? I should like to learn the experience of readers on this subject.
York, Pa. P. C.

ANSWER—My experience some years ago, before the guarding of belts was subject to state regulation as it is now, with a battery of belted Bliss presses

knocking out heads for condensed milk cans, may be of assistance to P. C. The girl operators complained about the "electricity" in the belts and how it attracted their hair, particularly as they passed along the aisle near the belts. Almost any time, it would be possible to place a finger near one of the belts and see a ½-in. spark jump between the finger and the belt.

To remedy this condition we attached strips of copper to the frames of the presses, but insulated from them, and carried a wire from these strips to the steam pipes along the wall back of the machines. Each machine had its strip and ground wire. There were no more complaints after that.

Another advantage which we found resulted was the reduction in the loss from burned-out lamps in the drop lights for each machine. These lamps were close to the belts and in some way the static in the latter had a bad effect on the filaments (drew them to one side, we thought) and they would burn out in about a week. After the grounds were put on there was no more trouble with these lamps than with any other lights in the plant.

With the sewing machines in question, I believe that P. C. should ground the static before it gets to the machines. Presumably, this could be done by a grounded "busbar" running along under the bench and near the belts, or close enough to solder fingers to it, which would come near the belts, and in this way eliminate the static trouble. DONALD A. HAMPSON.

Plant Superintendent,
Morgans & Wilcox Mfg. Co.,
Middletown, N. Y.

Motor Hum Reduced on Large Ventilating Fans

QUESTION.—In the operation of induction motors the lower the speed the greater the motor hum. In some cases however, it is necessary to use low-speed induction motors on ventilating fans and in this case excessive motor hum is objectionable since it is transmitted through the fan and to the duct system. If readers have devised ways and means to reduce the transmission of this hum by suitable mountings for motors when direct connected to the fan by using some fibrous or other material that reduces the transmission of noise, I would like to get details of such mountings. Possibly the noise-reducing device may take some form of coupling between the motor and fan. Please indicate also how magnetic density and variations in slip to get low-speed operation effect motor hum.
Omaha, Neb. H. A. P.

ANSWER—Replying to H. A. P.'s question, induction motors are subject to magnetic noises due to the varying magnetic densities in the iron caused by the alternating currents. I believe this trouble can be helped considerably by using sound-insulating material in the foundation directly under the motor base. Foundations

of cork pads 2 or 3 in. thick, felt pads, or sheet lead are some suggestions. Some reputable manufacturers of sound-insulating materials have studied this question of eliminating the magnetic hum caused by a.c. motors, particularly with reference to elevator motors used in large office buildings, hospitals, hotels, and the like, where noise of this nature is objectionable. As a suggestion, I might say that acoustic engineers connected with some of these companies have made careful investigations of this trouble and will doubtless be very glad to furnish valuable information on this subject.

R. F. EMERSON.

Industrial Engineering Dept.,
General Electric Co.,
Schenectady, N. Y.

Measurements Required for Bending Conduit

QUESTION.—When bending conduit by use of a hickey, what measurements should be taken for making an offset, so that I can bend several conduits and have them match when placed side by side? I find it hard to get both sides the same on a double offset. Can some reader tell me how I can make a good-looking job by the use of a hickey on this kind of bending? If any readers have other devices or methods for making double bends and offsets I should like very much to know about them.

Worcester, Mass. R. S. T.

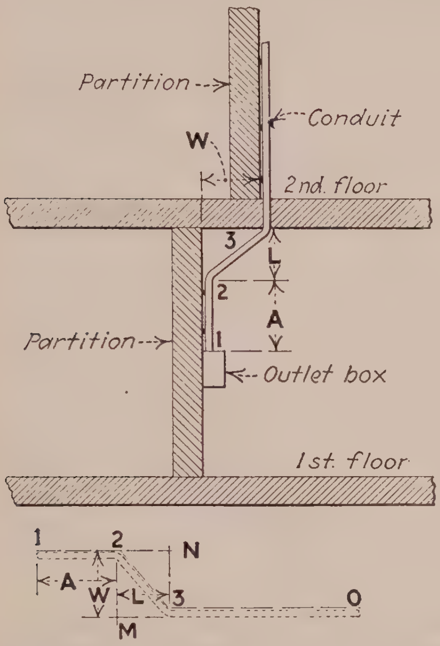
ANSWER—In answer to the question asked by R. S. T. I have used the following method with very satisfactory results.

For example, assume that a conduit is to be installed as shown in the accompanying illustration. It is to be run from an outlet box on the wall of the first floor, as at point *1*, up to the wall to the offset and then run up through the second floor and extend upward along the partition on this floor, as is shown in the diagram. To make an offset in a conduit so as to fit this location accurately, the procedure is as follows: First, measure the distances *A* and *L* between the points *1* and *2*, and *2* and *3*, respectively. Make the distance *L* as short as possible. Then measure the distance *W* between the wall on the first floor and the wall on the second floor; this is, in reality, the distance offset by the two walls.

Then upon the floor or any flat surface that is convenient, lay off these distances as measured. In the bottom diagram these distances are laid off, the distance *A* being laid off as a straight line between points *1* and *2*, the distance *W* being laid off at right-angles to *A* between the points *2* and *M;* the distance *L* is laid off on an extension of the lines *1-2* between the points *2* and *N*. The line *N-3* is drawn in perpendicular to the line *1-2-N;* likewise line *M-3* is drawn in perpendicular to the line *2-M* to form the rectangle, *2-N-3-M*, as is shown in the diagram. The line *M-3* is then extended to the right, as is also shown in the diagram.

The diagonal to this rectangle is now drawn as

shown at *2-3*. Conduit must then start at point *1* and follow along the line *1-2* until it reaches point *2;* it is then bent down to follow along the line *2-3* until it reaches point *3*, where it is then bent up or offset to follow an extension of the line *M-3* which is parallel



Measurements that should be taken and methods of laying them out to insure making accurate offsets in conduits.

to the line *1-2*. In other words, the line *1-2* represents the partition on the first floor and the line *3-O* represents the partition on the second floor. The line *N-3* represents the ceiling of the first floor, while point *2* is the point at which the offset or first bend is started. From this diagram the total length of conduit required can be measured directly according to the dimensions obtained.

In making the offset in the conduit, first place one end of the conduit at point *1* and at point *2* mark the conduit for making a bend. After making a bend by means of a hickey at point *2* until the conduit has been bent so as to coincide with the line *2-3*, point *3* can be marked on the conduit for the second bend. Then with the hickey at point *3*, bend the conduit upward until it coincides with the line *3-O* as shown in the diagram.

This is an exceedingly simple method of measuring

and making an offset so that it will fit on the first trial and thereby eliminate unnecessary climbing of ladders and waste of time in trying and fitting, as prevails under the bend-and-try method and which also makes it difficult to do a good job.

By measuring the distance *A* one can avoid the necessity of cutting a short piece of conduit to piece out to the required distance. Special pains should be taken in measuring the distance *W* to insure that the exact distance is obtained between the two walls against which the conduit is to lay. The accuracy of this measurement makes all of the difference between a neat-appearing and a poor installation.

OVIDE C. HARRIS

Plant Electrician,
Freiberg Mahogany Co.,
New Orleans, La.

Driving One Generator with Two Engines

QUESTION.—Can some reader suggest a practical and efficient method of driving a 50-kw. alternator by two oil engines of 37½ hp. and 50 hp., respectively, so that either or both engines may be used singly or together? If it is possible to devise such a drive with these engines operating singly or together I would have a selection of three horsepower capacities, 37½, 50, 87½, with which to meet the power demands. The peak load is about 45 kw., but the load is often much less than this. With such an arrangement it would not be necessary for me to buy a second alternator and install synchronizing equipment. I shall be very grateful for any advice or suggestions you can give me.

Youngstown, Alta., Can. W. C. A.

ANSWER—In answer to W. C. A.'s question, I would like to tell him of an installation that was used for a number of years in a rolling mill in the Birmingham district. The mill was driven by an engine and a motor; they were placed in line one behind the other. The engine was behind the motor and had a larger pulley; so it was easy to place the motor drive pulley between the two sides of the belt on the engine. As the speeds of the engine and motor were different, the pulleys were also of different diameters. The motor belt was next to the pulley and the engine belt ran on top of the motor belt. This drive gave satisfaction and was a good way to utilize the two prime movers.

To adopt this method of drive to your problem, I would suggest that you put a clutch on both engines and drive the generator in the same manner as outlined above. Or the generator shaft could be extended and an engine fastened to each end. If this method of drive were used, there would have to be some kind of clutch or magnetic coupling between the engine and generator to allow either engine to be used independently of the other. I believe, however, that a belt drive would be the most satisfactory, as the two engines probably run

at different speeds and this condition could easily be taken care of with a belt drive. GRADY H. EMERSON.
Birmingham, Ala.

Preventing Corrosion of Iron Storage Battery Racks

QUESTION.—I should like to ask your readers what treatment can be given to iron racks for storage batteries which will prevent the spilled acid from attacking the iron. We use the lead type of battery filled with dilute sulphuric acid. We have a large number of storage batteries and recently some iron racks have been constructed. All of these racks were painted with several coats of the best grade of asphaltum black paint but this does not protect the iron when acid is spilled on it, nor does any kind of paint that I have tried. We have had considerable trouble due to the corrosive effect of the acid forming a substance resembling sand which falls into the jars below. This produces excessive iron in the solution, making a change of acid necessary. I shall appreciate it if anyone can tell me how to overcome this.
Atlanta, Ga. J. B.

ANSWER—In reply to J. B.'s question, as the result of experimenting with several different preparations in an effort to prevent corrosion of battery racks and busbars I would suggest that he thoroughly clean off all old paint and corrosion from the attacked parts and then wash them with a solution of bicarbonate of soda. Dry thoroughly and apply two coats of Pyramid Acid Resistor Paint, either flat or gloss, or both.

If he does this I am sure that the trouble from corrosion will disappear. I have experienced J. B.'s trouble and I sympathize with him. It is very annoying and hard to overcome.

The Pyramid paint I mentioned can be obtained from the Pyramid Paint Co., Philadelphia, Pa.

F. J. H. KRAUSE.
Dallas, Tex.

Vacuum Pump Used as Air Compressor

QUESTION.—I have a Wahl vacuum pump, size 4 in. by 2½ in., with ¾-in. inlet and outlet, which I wish to use as an air compressor. The pressure in the air tank need not go over 125 lb. per sq.yd. Will someone please tell me (1) What size motor would be required to drive this pump at 275 r.p.m. (2) Will it be necessary to make provision for cooling this pump artificially, by means of air fins or water, in order to keep the temperature down to a safe limit? (3) How do you figure the cubic inches of air compressed per stroke?
Dallas, Tex. R. E. L.

ANSWER—The formula for the required thickness of a cylinder subjected to internal pressure is $t=(P\times d)\div(2\times S)$, in which t is the thickness of cylinder wall in

inches, P the pressure per sq.in., d is the bore of the cylinder in inches and S the working strength of the material.

In the case that was under discussion, with P—125 lb., $d=4$ in., and S (cast-iron) $=2{,}500$ lb., the required thickness is $t=(125\times4)\div(2\times2{,}500)=0.1$ in. Surely, the cylinder wall is 0.1 in. in thickness. Because of practical considerations, the thickness of the wall of the cylinder of R. E. L.'s vacuum pump is probably not less than 0.5 in.; so it would seem that strength is not an important consideration.

A compressor of the size under discussion would probably have a volumetric efficiency of about 75 per cent; so the capacity at 275 r.p.m. would be (assuming a single-acting machine) 3.75 cu.ft. free air per minute.

Single-stage compression to 125 lb. is not considered good practice because it is less efficient than two-stage compression and, worse still, produces a temperature that is destructive to lubricating oil. The adiabatic temperature of air compressed to 125 lb. gage, is above 500 deg. F.; so any system of cooling that R. E. L. succeeds in applying to this compressor will probably not prevent some trouble in maintaining lubrication.

C. O. SANDSTROM.

Los Angeles, Cal.

Air Filter for Intake of Air Compressor

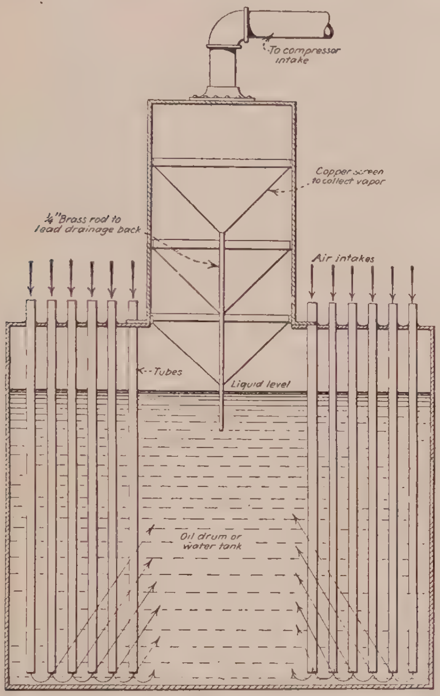
QUESTION.—I should like to get a little information from someone who may be inclined to lend a helping hand. The plant where I am employed has installed two feather-valve air compressors. These compressors are subjected to coal dust, coal smoke and sand and we are having trouble with the valves. After cleaning them they operate satisfactorily for about 24 hours, and then begin to hang and stick. Will someone please give me complete details of a suitable screen or air filter that I could make and use on the intake of these compressors?

Norfolk, Va. W. B. E.

ANSWER—With reference to W. B. E.'s question, I would suggest that he procure an old, steel oil or water tank of about 75-bbl. capacity and weld in place a large number of tubes, as shown in the illustration. These tubes may be suitable lengths of pipe and should extend to within 2 or 3 in. of the bottom of the tank, which should be partly filled with water, or oil if it will be exposed to low temperatures. The upper end of the tubes should, of course, be open so that they will serve to conduct the incoming air through the liquid in the tank and thus free it from dust and other foreign matter. Without knowing the size of the compressor in question, it is not possible to give the size and number of tubes, but I do not believe that they should be larger than 1 in. in diameter. W. B. E. should put in enough tubes to make their aggregate area somewhat larger

than the area of the compressor intake. The more tubes that can be conveniently placed in the tank the better, as the resistance to the passage of the air will be reduced and less vapor will be carried over.

It would also be necessary or advisable to mount on



Suggested method of filtering intake air for air compressor by passing it through water or oil.

top of the tank, over the manhole, a dome which should serve as the outlet for the filtered air and be connected to the air intake of the compressor. This dome should be built of ¼-in. boiler plate and made air tight. It should contain fine wire screen which would serve to stop vapor and liquid particles from being drawn over into the compressor.

I believe a device of this sort would solve W. B. E.'s problem, providing that he constructs one which will be large enough to supply the compressors without too much liquid being drawn over. In any event, I hope that this suggestion will be of some help to him.

E. L. WAY.

Marietta, Ohio.

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